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YELLOW FEVER COMMISSION

(WEST AFRICA)

INVESTIGATORS' REPORT.

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YELLOW FEVER COMMISSION

(WEST AFRICA)

III

REPORTS

ON QUESTIONS CONNECTED WITH THE

INVESTIGATION OF NON-MALARIAL FEVERS IN WEST AFRICA

VOLUME III.

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REPORT OF THE ENTOMOLOGICAL INVESTIGATION UNDERTAKEN FOR THE COMMISSION FOR THE YEAR, AUGUST, 1914, to JULY, 1915.

BY

A. W. BACOT, F.E.S.

(*Entomologist to the Lister Institute of Preventive Medicine*).

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REPORT OF THE ENTOMOLOGICAL INVESTIGATION UNDERTAKEN FOR THE COMMISSION FOR THE YEAR, AUGUST, 1914, to JULY, 1915.

BY

A. W. BACOT, F.E.S.

(Entomologist to the Lister Institute of Preventive Medicine).

I.—INTRODUCTION.

The work with which this Report deals was carried out at Freetown, Sierra Leone, between the months of August, 1914, and August, 1915. A few experiments, for which there were no suitable facilities at Freetown, were performed at the Lister Institute of Preventive Medicine during October, 1915, with material resulting from eggs brought home from West Africa.

The original scheme of work in connection with the incidence of Yellow Fever in West Africa had to be largely modified owing to the outbreak of War. In the absence of clinical and pathological workers to co-operate with, the greater part of the energies of the entomological section were devoted to the elucidation of questions concerning the bionomics of *Stegomyia fasciata*, the main endeavour being to supplement and substantiate the already very considerable knowledge of the life history of this species, which we owe to Finlay, Goeldi, Reed and Carrol, Boyce, Newstead, Dupree and the members of the French Committee, as well as numerous other workers.

Time did not permit of the investigation of problems connected with the possibility of a seasonal variability. For instance, the tendency of eggs sometimes to hatch immediately they are placed in water, and at others to defer hatching for an indefinite period; or, again, the question of the period for which different batches of eggs remain viable, may be associated with the season of the year in which the parents producing the eggs are reared, but to clear up these and similar points would necessitate the continuance of the research over several seasons.

Charts of the temperature and humidity records in the various places where experimental work was carried out will be found in the

section dealing with the length of the adult life (pages 64 and 92-101). Owing to delays in despatch and transit the thermometers were not available during the earlier months of the research. In order to give some idea of the conditions during the months of August, September, October and November, a summary of the general meteorological observations in Freetown for the year 1914 is included. The temperature of the water used for egg hatching and larvæ breeding would be, unless stated to the contrary, about 80° F.

It is with much pleasure that I avail myself of this opportunity of expressing my thanks to the members of the West African Medical Staff for their kindness in endeavouring to make my tour as pleasant and effective as possible; to Dr. W. Allan and Dr. J. S. Pearson and other friends, for placing at my disposal collections of mosquito larvæ taken in Freetown, and especially to Dr. G. G. Butler, who, in spite of the exceptional pressure of official work, brought me many collections of larvæ that he had made in the district surrounding Hill Station.

From the material collected and bred at Freetown sets of specimens of the prevalent species of mosquitoes were forwarded to the Liverpool and London Schools of Tropical Medicine, and to Mr. F. W. Edwards, of the British Museum of Natural History a small collection of specimens which it seemed possible might be of service to the National Collection. Amongst this latter material was a new species of *Eretmopodites*, of which Mr. Edwards is publishing a description in the "Bulletin of Entomological Research," Vol. VI., Part 4, page 362.

I take this opportunity of acknowledging my indebtedness to Mr. Edwards' (1912) "Keys of the African *Culicidæ* other than *Anopheles*," which I found of great assistance, and my thanks are due to their author for his kindness in checking and confirming my determinations.

My thanks and acknowledgments are also due to Messrs. Bruce F. Cummings, W. L. Distant, Stanley Hirst, G. Meade Waldo, D. J. Scourfield and H. M. Woodcock, for assistance in identifying species dealt with in this Report.

II.—INTRODUCTORY NOTES ON THE DISTRIBUTION OF MOSQUITOES IN FREETOWN (SIERRA LEONE) AND ITS VICINITY.

Mosquitoes are so far from being the omnipresent nuisance in Freetown that one is led to expect in the Tropics generally, and on the West Coast of Africa in particular, that there is a danger of being lured into a false sense of security leading to the lapse of all precautions.

Their apparent absence and actual rarity are partly due to the natural advantages conferred by the porous nature and contour of the soil, and largely to the efficiency and activity of the Sanitary Department in the inspection of compounds and the destruction of larvæ. The evidence afforded by a mosquito hunt beginning in the central area of the town and extending beyond its bounds is eloquent in its testimony of what has been accomplished.

In the outlying areas of the town and the adjacent villages much remains to be done, especially in the matter of the efficient drainage of surface water.

General observation and search for adults lead to the conclusion that *Culiciomyia nebulosa* is the dominant species within the central area, but if the larval stages be included in the search, and the larval collections made by the Sanitary Department are taken into consideration, it soon becomes obvious that an adult census is but a poor guide to the actual facts.

As regards breeding and general distribution the species of *Stegomyia*, especially *fasciata*, easily lead. Any relaxation of the Sanitary Administration in the matter of mosquito work would inevitably be accompanied by a rapid increase in the adult *Stegomyia* population.

It is even now an open question if adults of *C. nebulosa* are really more numerous than those of *S. fasciata*. While the former is comparatively casual in its selection of resting places—any damp or shaded wall in an outbuilding will do, and its breeding habits tend to produce sudden and very noticeable outbursts of adults—*S. fasciata* is exceedingly careful and able in hiding away, while it begets larvæ with a steady persistency in any available breeding place without a sign of an adult being seen.

The *Anopheles* species, *Pyretophorus costalis* and *Myzomyia funestus*, are much more restricted in distribution and breeding grounds, although the places affected by the last-named are of large extent where they do occur. Larvæ of *P. costalis*, though common and generally distributed in rock and gutter pools, are few in number compared with the swarms of *S. sugens* larvæ which are present in these situations in the outlying districts of the town (*see* Plates 8, 10 and 11, pp. 12 and 13). They also occur not infrequently within its central area, and are sometimes met with in tins and even in water-holes in trees. *M. funestus* is restricted in its breeding places and is only occasionally present in isolated rock pools, its regular *habitat* being the shallow hard-bottomed swamps which occur on the laterite flats at the foot of the hills, both to the east and west of Freetown (*see* Plates 13, 14 and 15, pp. 14 and 16). During the rains the surface water flows slowly out from the foot of the hills across these flats, covering wide areas with water trickling through the roots of the grass and forming shallow pools at frequent intervals. The pools are often tenanted by tadpoles, the mosquito larvæ being chiefly found among the roots of the grasses—the frogs or toads with which these swamps abound being no doubt responsible for the absence of mosquito larvæ in the open pools. The surface water cut between Alligator River and Congo River to the south of the railway has benefited the western end of the town by drying a considerable area of the flats and thus restricting the possible breeding grounds of *M. funestus*. On the east, however, above Fourah Bay and along the rail to Kissy large tracts of these flats are still in their natural condition.

Holes in trees, a favourite breeding situation with several species of *Stegomyia* and *Ochlerotatus*, have received special attention in the past, so that it requires careful search to find any within the central area of the town (*see* Plates 1 and 2, page 6). Small rock pools are however, only too plentiful in its outer areas, and these, together with old and irregularly graded road side drains, constitute possible breeding places, which must be a constant source of anxiety to the sanitary authorities, pending the extension of the admirably designed newer drainage system to the outer districts of the town (*see* Plates 4, 5 and 8, pp. 8, 9 and 12). Tins, jars, bottles, tubs, etc., would still seem to be the chief strongholds of *S. fasciata*; fortunately, as indicated above, the vigilance of the compound inspections prevents more than a tithe of the larvæ reaching maturity.

Plants.—The axils and central whorl of leaves of a number of plants provide breeding accommodation for a certain number of species during the rains. Of these, *Uranotænia ornatus* and a new species of *Eretmopodites** seem to be restricted to the water in these plant reservoirs. *Stegomyia simpsoni*, though most commonly reared from collections of larvæ taken from plants, certainly breeds in root holes also, while a few ubiquitous species, such as *Stegomyia fasciata* and *Culiciomyia nebulosa*, are occasional tenants.

The breeding of mosquitoes in plants opens up a difficult problem, as two of the plants, the banana and cocoa yam, are valuable sources of food supply, while another, the "Cock Hat" tree, a species of *Dracæna*, is a serviceable and largely used hedging plant. There are two species of this plant grown in Freetown and its vicinity, only one of which accumulates water in the central whorl and axils of its leaves; both species are used for hedging, but the water holder much more frequently than the other. Possibly there may be some advantage, such as speed of growth, but unless this is weighty it would be well to discourage its use (*see* Plates 16 and 17, page 17).

The feeding tendencies of the specimens reared from larvæ taken in these plants were tested in regard to their willingness to suck human blood. The abilities in this direction of *S. fasciata* or *G. nebulosa* (occasionally present) need no comment. *S. simpsoni* was found to be as insatiable as *fasciata*. *Eretmopodites* would feed lustily, but only at long and irregular intervals. *Uranotænia ornatus*, bred only from these situations, invariably refused to bite or feed at all, although offered both honey and syrup.

* Described by Mr. F. W. Edwards in the "Bull. of Entom. Research" under the name *dracænæ*.

MOSQUITO BREEDING POOLS.

Plate No. 1.
Roots of a Cottonwood tree. Tower Hill.

Plate No. 2.
Waterhole in the roots of the same tree. Larvæ of *Stegomyia fasciata*, *S. simpsoni*, *S. luteocephala*, *Ochlerotatus minutus*, *O. apicoannulatus*, *Culiciomyia nebulosa* and *Anopheles costalis* were taken from this pool.

LIST OF MOSQUITOES IDENTIFIED FROM VARIOUS LOCALITIES, MOSTLY BRED FROM LARVÆ.

Central Area of Town.

Tower Hill.

Larvæ from water holes in cottonwood tree (*see* Plates Nos. 1, 2 and 3, pp. 6 and 8) :—

Anopheles (*Pyretophorus*) *costalis*, Lw. ...	... two specimens.
Stegomyia fasciata, F.	... in numbers.
,, *simpsoni*, Theo.	... in numbers.
,, *luteocephala*, Newst.	... in numbers.
Ochlerotatus apicoannulatus, Edw. ...	... in numbers.
,, *minutus*, Theo.	... a few.
Culiciomyia nebulosa, Theo.	... a few.
Culex decens, Theo.	... in numbers during November.

Larvæ from rock pools (*see* Plates Nos. 4, 5 and 6, pp. 8 and 9) :—

Stegomyia sugens, Wied.	... swarms.
,, *fasciata*, F.	... several.
,, *luteocephala*, Newst.	... one specimen.

Compound at Colonial Hospital.

Larvæ in old tins and broken bottles :—

Stegomyia fasciata, F.	... numbers.
Culiciomyia nebulosa, Theo.	... numbers.

Yard, 26, Westmoreland Street.

Larvæ in tins, bowls, etc. :—

Stegomyia fasciata, F.	... numbers.
Culiciomyia nebulosa, Theo.	... two or three broods.
Eretmopodites quinquevittatus, Theo. ...	... several.

Gloucester Road.

Surface water drain :—

Anopheles (*Pyretophorus*) *costalis*, Lw. ...	... one specimen.

Circular Road.

Surface water drain :—

Anopheles (*Pyretophorus*) *costalis*, Lw. ...	... one specimen.

MOSQUITO BREEDING POOLS.

Plate No. 3.
The root hole in Cottonwood tree filled with cement.

Plate No. 4.
Rock Pool which contained larvæ of *Stegomyia sugens*. Tower Hill.
The white streak is a foot rule.

MOSQUITO BREEDING POOLS.

Plate No. 5.

Rock Pool which contained larvæ of *Stegomyia sugens*, *S. fasciata*, and *S. luteocephala*. Tower Hill.

Plate No. 6.

The same pool filled with cement.

COLLECTIONS OF LARVÆ RECEIVED FROM VARIOUS HOUSES AND COMPOUNDS IN THE CENTRAL AREA OF THE TOWN, INCLUDING THE REST HOUSE AND NURSING HOME.

Stegomyia fasciata, F. ... ... numerous.
Culex tigripes, Grp. ... ... two or three.
Culiciomyia nebulosa, Theo. ... . numerous.

Campbell Street.

A tin from a compound :—

Megarhinus (*Toxorhynchites*) *brevipalpis*, Theo. one specimen.
Ochlerotatus apicoannulatus, Edw. ... ... several specimens.
Stegomyia frazeri, Edw. ... ... one specimen.

Post hole near Saunders Brook.

Stegomyia sugens, Wied. ... ... numbers.

Hill Station.

Rock pools :—

Anopheles (*Myzomyia*) *funestus*, Giles ... ... two or three.
Stegomyia sugens, Wied. ... ... numbers.
Ochlerotatus minutus, Theo. ... ... swarms.
,, *simulans*, Cart. ... ... one specimen.

Water hole in a tree :—

Stegomyia frazeri, Edw. ... ... one specimen.
Ochlerotatus minutus, Theo. ... ... numbers.

Lumley Road.

Bolt holes in cement foundation of sand elevator :—

Stegomyia sugens, Wied. ... ... numbers.
Culiciomyia nebulosa, Theo. ... ... numbers.

Wilberforce.

Old bottle, wayside ditch :—

Stegomyia fasciata, F. ... ... numbers.

Old tins, rubbish heap :—

Ochlerotatus minutus, Theo. ... ... numbers.
Eretmopodites quinquevittatus, Theo. ... ... several.
,, *chrysogaster*, Grab. ... ... a few.
,, *inornatus*, Newst.... ... ... one specimen.

Rock pools on wayside boulders (*see* Plate No. 7, page 11) :—

Anopheles (pyretophorus) costalis, Lw. ... ... one or two.
Stegomyia sugens, Wied ... ... numbers.
,, *luteocephalus*, Newt. ... ... a few.

ROCK POOL NEAR WILBERFORCE STATION.

Plate No. 7.

A breeding hole on a boulder on Wilberforce Hill; larvæ of *Stegomyia sugens*, *S. lutveocephala* and *Anopheles costalis* were taken here. The white streak is a foot rule measure showing the small size of the hole.

Murray Town

Road side rock pools :—

Anopheles (pyretophorus) costalis, Lw. ...	... several.
Stegomyia sugens, Wied.	... numbers.
„ *fasciata*, F.	... numbers.

Cline Town.

Small tank in a compound :—

Anopheles (pyretophorus) costalis, Lw. ...	... several.
Culex tigripes, Grp.	... one or two.
Ochlerotatus apicoannulatus, Edw. ...	... a few.

MOSQUITO BREEDING POOL.

Plate No. 8.

Pools of water in bed of surface water drainage channel near Kissy Road Cemetery; contained larvæ of *Stegomyia sugens* and *Anopheles costalis* in May. In July this channel was the bed of a torrential brook.

BREEDING GROUND OF *ANOPHELES* MOSQUITOES.

Plate No. 9.

Swampy flats between Kissy Road and Fourah Bay. Suitable breeding ground for *Anopheles* mosquitoes. Washing in progress in the distance.

BREEDING GROUNDS OF *ANOPHELES* MOSQUITOES.

Plate No. 10.

Rock Pools on these flats: *Anopheles costalis* and *Stegomyia argens* were breeding here.

Plate No. 11.

Another view of the rock pools on the flats between Kissy Road and Fourah Bay.

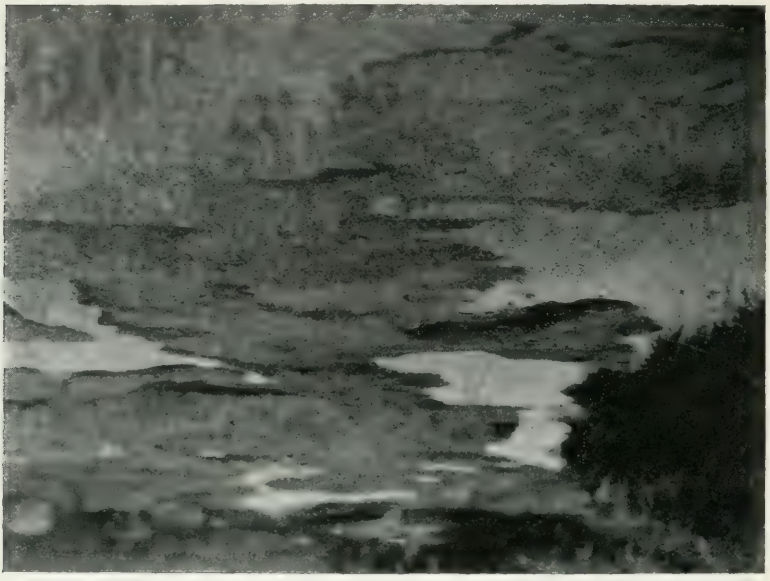


Plate No. 12.

Details of the rock pools shown in Plate 10. Contained larvæ of *Stegomyia sugens* and *Anopheles costalis.*

Plate No. 13.

View of Kissy flats, near the Station. Breeding grounds of *Anopheles funestus.*

Kissy Road.

Rock pools in wayside gutter near the cemetery (*see* Plate No. 8, page 12) :—

Anopheles (Pyretophorus) costalis, Lw. ... ... several.
Stegomyia sugens, Wied. ... ... numbers.

Flats between Kissy Road and Fourah Bay (*see* Plates Nos. 9, 10, 11 and 12, pp 12-14) :—

Rock pools in shallow running swamp :—

Anopheles (Pyretophorus) costalis, Lw. ... ... numbers.
and probably *Myzomyia funestus*, Giles ... larvæ not reared.
Stegomyia sugens, Wied. ... ... swarms.

Kissy.

Rock pools in swampy lane :—

Anopheles (Pyretophorus) costalis, Lw. ... ... numbers.
Stegomyia sugens, Wied. ... ... swarms.

Pools in gutter by side of railway track :—

Anopheles (Pyretophorus) costalis, Lw. ... ... numbers.
Stegomyia sugens, Wied. ... ... swarms.

Shallow hard bottomed running swamps (*see* Plates Nos. 13, 14 and 15, pp. 14 and 16) :—

Anopheles (Myzomyia) funestus, Giles. ... ... larvæ captured in twos and threes over large areas.

THE FOLLOWING SPECIES WERE REARED FROM LARVÆ TAKEN FROM PLANTS IN DIFFERENT PARTS OF FREETOWN :—

Cocoa Yam.

Stegomyia simpsoni, Theo. ... ... common.
,, *fasciata*, F. ... ... a few.
Culiciomyia nebulosa, Theo. ... ... occasionally. When present, usually in numbers.
Uranotænia ornata, Theo. ... ... common.
Eretmopodites dracænæ, Edw. ... ... a few.

"*Cock Hat*" *Tree* (*see* Plates Nos. 16 and 17, page 17) :—

All the above species with the exception of *S. fasciata*.

Eretmopodites dracænæ, Edw. ... ... very common.

Banana.

Stegomyia simpsoni, Theo. ... ... not numerous.

Sarsaparilla.

Stegomyia fasciata, F. ... ... in numbers.
Eretmopodites dracænæ, Edw. ... ... a few.

BREEDING GROUNDS OF *ANOPHELES* MOSQUITOES.

Plate No. 14.
Another view : Kissy Village in the distance.

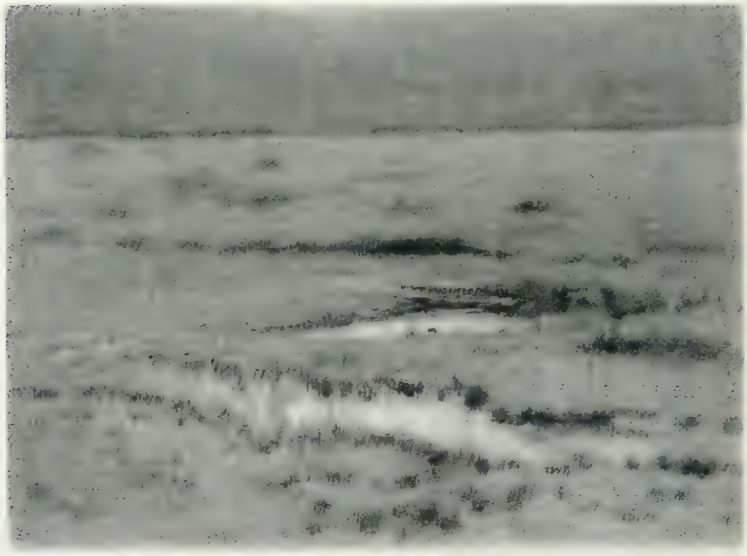


Plate No. 15.
Pools in the trickling swamps at Kissy Flats.

A PLANT WHICH AFFORDS BREEDING PLACES FOR MOSQUITOES.

Plate No. 16.

"Cock Hat" Trees; a species of *Dracæna*. The species in the foreground collects water in the central whorl and axils of the leaves. The stiffer leaved variety in the background holds no water.

Plate No. 17.

"Cock Hat" Tree. Affords breeding place for *Stegomyia simpsoni*, *Uranotænia ornatus* and *Eretmopodites dracænæ*. *Stegomyia fasciata* and *Culiciomyia nebulosa* are also occasional breeders in this and other plants.

III.—BIONOMICS OF *S. FASCIATA.*

(*A*) EGGS.

General Notes.

The eggs of *Stegomyia fasciata* are small black spindle-shaped objects, which, as has been so frequently pointed out, are laid singly. They vary very considerably in size and shape, so that it is possible to pick out examples which in form and size closely approximate to the eggs of *S. sugens*, *S. simpsoni* or *S. luteocephala*, all of which differ from each other and, so far as the limited number of eggs of these species obtained is concerned, do not vary greatly individually in either size or outline. A noticeable feature of typical eggs of *S. fasciata* is that in one of their aspects they are slightly asymetrical, bow-shaped in outline, one side being flatter than the other.

FIG. 1.

Outlines of the eggs of *S. simpsoni*, *S. sugens*, and *S. luteocephala*, showing the difference in shape and size between the eggs of these species, and an average egg of *S. fasciata*. The dotted outline is that of the egg of *S. fasciata*.

Size.—The measurements of the normal eggs of *S. fasciata* are about ·630 to ·650 mm. in length and ·160 mm. at the greatest diameter. Small eggs, frequently of stumpy form, are sometimes laid of scarcely more than two-thirds the normal size, while large eggs, measuring up to ·8 or ·9 mm. long and proportionately thick, are occasionally to be found. The diminutive eggs are generally, though not always, laid in batches by females all of whose eggs are small, and they frequently either do not hatch at all or show a high

percentage of infertility. The giant eggs, on the other hand, are never laid in batches, but occur in twos and threes among eggs of more normal size and usually hatch. Pale, colourless, presumably immature eggs are occasionally found in batches of eggs which are of the normal colouration—these appear to be invariably infertile. Normally, however, all the eggs laid are either already dark when deposited or darken with great rapidity. The egg masses within the ovaries of the mosquitoes are usually colourless, but in many instances the ovaries of dissected mosquitoes were found to be already pigmented, usually of a bright brown. In England the number of white eggs seen after deposition suggests either that eggs were laid when less matured, or that the development of pigmentation is in some cases much less rapid, possibly owing to the lower temperature.

Surface Sculpturing.—The surface of the egg is covered with a delicate cellular reticulation formed by thin walls of chitin. From the centre of each cell space over the greater portion of the area arise hemispherical bosses. At the blunt end the cellular reticulation is produced to form a low wall surrounding the micropylar area of the egg.

The Bosses.—The bosses within the cell walls are not merely structural irregularities of the egg wall, but are definite masses of a stainable substance, probably of a colloidial nature. Sections of the eggs within the ovary show that these bosses are apparently formed in pockets of a delicate inner membrane which enshrouds the egg.

The purpose of the structural features of the eggs of *Stegomyia* is usually assumed to be connected with the floating of the eggs, which are heavier than water and sink once they are freed from the surface film of water. In view, however, of the fact that surface structure of the shell alone would be quite sufficient, as in the case of other insect structures, to meet all the requirements connected with adjustment to the surface film, it seems not improbable that the bosses may serve an entirely different purpose to the cellular reticulation with which they are associated. This purpose may possibly be connected with the insulation of the egg from heated surfaces on which it rests, or, as seems more probable, with the ability of the eggs to resist desiccation.

In this connection it may be noticed that shrunken eggs, the sides of which are collapsing, often contain living larvæ, and, further, that such eggs will regain their full rotundity when placed in

water, while after regaining their original shape they may still defer hatching to a later period. The suggestion is that by means of these bosses the egg is enabled to absorb moisture if wetted by rain or dew.

Situation where eggs are laid.—The eggs of *Stegomyia* are generally stated to be laid on the surface of the water. This may very possibly be accurate in the strict sense of the word, in that there is always a film of water present on which the egg is laid. Certainly no instance of an egg being laid on a dry surface has occurred with the thousands laid by captive females in the course of this research, and very few were ever laid in receptacles containing honey or syrup for the adults, even when there was no other liquid available for oviposition. As a general statement, however, it is misleading to say that the eggs are deposited on the surface of the water, as in the great majority of cases they are to be found on the wet margins of the receptacle containing the water, or of some partially submerged object, such as a leaf or twig. These situations suggest that they are either deposited on the margin itself—in some instances there was definite proof that such was the case—or on the water in such close proximity to the margin that capillary action on an evaporating surface inevitably strands the greater proportion of them.

The general position during oviposition would seem to be for the female to rest on the margin with her back to the water. In certain instances, however, the eggs are widely scattered over the water surface suggesting that they are deposited while the female walks on the water. All the evidence from the laying of eggs on wet filter paper points to the fact that they are deposited while she rambles about. It may be mentioned while dealing with this point that the eggs appear to hatch equally well whether resting at the bottom, floating, or attached to the margin beneath the surfare. Only a single instance of a female laying her eggs in a cluster on the surface of water was observed. In this case the female had thrust one or more of her legs through the surface film and was found lying on her side in a bogged condition alongside her eggs. The laying of eggs in clusters would seem to be of rare occurrence.

A few eggs, presumably only a small proportion of those laid on the water surface at its margin, sink at once. Others that have been laid or stranded on the steep or vertical sides of breeding pans are washed down, some sinking, while the remainder are restranded.

No doubt under natural conditions, where the range of circumstances is less restricted, the figures may be less one sided, but with

PHOTOGRAPHS OF EGGS OF *STEGOMYIA FASCIATA*.

Photo by F. Noel Clark.

Plate No. 18.

Eggs of *Stegomyia fasciata*, laid on leaf of Cottonwood tree. ×20.

Photo by F. Noel Clark.

Plate No. 19.

Egg of *Stegomyia fasciata*, laid on leaf of Cottonwood tree. ×40.

the methods adopted for rearing in this research by far the larger proportion of the eggs deposited were either laid, or stranded by capillary action, on the filter paper covering sides of the breeding pans above water level, at an estimate quite 90 to 95 per cent. Even with such badly adapted margins for stranding as tins would appear to afford, rust and dirt quickly produce an absorbent surface which acts almost as well as filter paper for the attachment or stranding of eggs.

Distribution after laying.—Eggs laid in the hollows formed in the beds of small streams, ditches, runlets, or guttering will tend to be washed downwards with each successive shower of rain and collect in the larger and more permanent pools, cisterns or water butts, as the case may be, as the attachment of the eggs is precarious in the absence of any other cement than that afforded by water scum, which, though firm enough during dry weather, is easily soluble in rain water. Eggs laid in sheltered water holes, in tree trunks, rock pools or tins are less liable to be distributed, but even in these cases a certain number will be laid on fallen leaves, some of which may be scattered during dry periods. With undisturbed eggs the gradual rise of water level during the onset of rain affords ideal conditions to induce hatching by gradually wetting and then immersing them in cool water, while at the same time the number of larvæ hatching tends to be automatically adjusted to the quantity of water.

Hatching.—The egg shell is ruptured by a clean transverse break at about a quarter of its length from the blunt micropylar end. Sometimes the cap falls completely off, but more frequently it is left slightly attached to or lying against the shell like a hinged lid. As the level of this clean cut corresponds with the position of the egg breaker, or more properly cutter, on the head of the larva, there can be little doubt as to the origin of the rupture in the shell which allows the larva to emerge. There are, however, some minor points connected with hatching which would seem to suggest automatic action on the part of the egg case and its contents apart from voluntary movement of the larva at the moment of its emergence.

In a number of cases eggs which had undergone long periods of dry storage, or had been submitted after long resistance of other methods to cooling, hatched, but yielded larvæ so feeble that they speedily died.

Eggs hatched under the influence of salt water show a considerable proportion which uncap although the larvæ do not emerge*. Again

* This also occurred to eggs that had been exposed to Formaline vapour for 24 hours.

there is the existence of what may be termed a time zone system in the hatching of resistant eggs. They do not respond to the repetition of *stimuli* at short intervals in the same marked manner that they show if the repetition occurs after a considerable lapse of time. And further, as will be shown later in Experiment No. XVIII., there is evidence that the latent tendency to defer hatching, which is probably hereditary, may be considerably influenced by external conditions after incubation.

In the light of these considerations it seems possible that the larvæ, which appear to be fully developed within 40 hours of the laying of the egg*, differentiate as regards the period when they perform the operation of incising the shell, those that have already performed this operation being ready to respond to external *stimuli* at once, while the others must delay until the necessary action is performed or defer indefinitely because the conditions have ceased to stimulate before the operation is completed.

It seems questionable to what extent volitional action on the part of the larva is responsible for the final uncapping of the egg. Sometimes the larva emerges with a "Jack-in-the-box"-like celerity, at others it will remain quiescent for a minute or so and then quickly and easily get free, or it may feebly and slowly struggle out.

Experimental Evidence Relating to the Hatching of Eggs.

The experimental evidence concerning the hatching of eggs is to a considerable degree bound up with questions of egg laying and fertility, which belong rather to the section dealing with adults. This is especially the case with the two preliminary Experiments, Nos. I. and II., which are included in this section, as they preface the whole of the experimental work dealing with hatching as well as that concerning egg production and fertilization; the chief value of these provisional experiments being in regard to the questions raised during their progress and the basis thus afforded for planning better controlled tests.

* In Freetown at a temperature of 80° F.

Experiment No. III.

HATCHING OF EGGS LAID BY A WILD FEMALE OF *STEGOMYIA FASCIATA*.

A living female was found "bogged" on the surface of the water contained in a biscuit tin (at 26, Westmoreland Street). Her feet had broken through the surface film, and in this trapped position she had laid a batch of 59 eggs. In the light of later experience, the position in which the eggs were laid and their arrangement was most unusual; at the time it was thought that this was a normal instance of egg laying. The eggs were taken up on a slip of filter paper and a camera drawing of the arrangement of the eggs as laid was prepared. The batch was carefully submerged in a glass dish containing 200 c.c. of tap water.

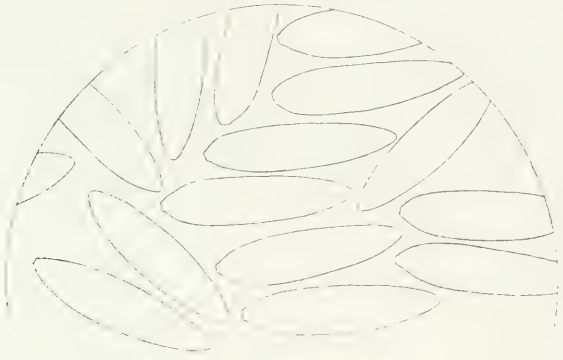


FIG. 2.

Date of laying.	Number of eggs.	Date of hatching.			
		September.		October.	
		27	28	5	12
24th September ..	59	35	3	**17**	**3**

REMARKS AND NOTES.

The block figures indicate that hatching followed after a break in the continuity of the conditions.

On the 4th October the pan was refilled with fresh water, and on the 12th the eggs were lifted from the water for a space of four hours and allowed to dry; they were then re-immersed in the same water.

One egg remained unhatched; this was taken from the water on the 17th October, dried and then returned to the water. This was repeated on the 23rd October, and again for the fourth time a few days later. As the egg

nities of feeding on human blood were afforded each night.

ans than the others and equal in size.

been made in this situation it is probable that this batch

apsed on drying.
but one collapsed, this egg was opened and found to contain a larva.
ney were kept in water and collapsed when dried.
h October.
pt in water and collapsed when dried.
he same day is very unusual.
h October.
llapsed ; this egg was returned to the water and hatched on the following

October.
th October.

ned eggs except three collapsed. These three were returned to the water
ed on 9th November and immersed on January 15th, and failed to hatch,
apsed.
16th October.
18th October.
rying on the 23rd October.
er.
did not collapse they were stored on the 9th November, 1914, but were

eggs but one collapsed, this egg resisted altogether five dryings and
the 9th November until the 30th December, when it was found to have

atched eggs which did not collapse. None of these hatched on the third
on the 9th November, 1914, but were dead when opened in May.

or three weeks, they were then dried ; all collapsed.

---

e hatching on the 19th and 35 on the 22nd October, was
he 18th and 21st October respectively. In this instance
hell within 10 minutes of their being placed in water.
20 larvæ that emerged on the 24th and 1 on the
of this batch on the 23rd, and its re-immersion on the
re out within 10 minutes of the eggs being returned to

PRELIMINARY EXPERIMENT REGARDING THE LAYING AND HATCHING OF THE EGGS OF *STEGOMYIA FASCIATA*.

Two females and several males used

The first female emerged 26th August, 1914; the second on the 31st September, 1914.*

The first male emerged 30th August, 1914; the second on the 9th September, 1914. Other males were placed with the females when these matured. Opportunity for feeding on human blood were afforded each night

The eggs were collected early in the wet filter paper on which the glass jar containing the mosquitoes was inverted

The eggs were submerged in water, none were allowed to remain floating

All the eggs were submerged in separate glass dishes of various sizes, except the three laid on 12th, 13th and 14th September (Nos. 6, 7 and 8), these were in large dishes with the others and reared in one.

Batches 1 to 6 were kept in separate glass dishes of various sizes, except the three laid on 12th, 13th and 14th September (Nos. 6, 7 and 8), these were in large dishes with the others and reared in one.

Batches 7 to 13 separate from each other in small glass dishes were all submerged in one large pan

Batches 14 to 19 separated from each other in small glass dishes were all submerged in a second large pan

Batches 21 to 30 kept in separate dishes.

† *Batch* No. 14. These 250 eggs, put down under date of the 22nd September, were collected from the rim of the jar. As in previous search for eggs had been made for this situation it is probable that this batch represented an accumulation covering several days. This situation was subsequently searched each day.

| | | |

ONLY ONE FEMALE WAS USED.

mber.
days).

onditions in regard to quantity and temperature of water.

Remarks and Notes.

October without any apparent effect.

oyed after removal from the pan on 17th October.
r.
th, 10 hatched in 10 minutes, 1 later in the day, 1 the next day. Of the two
third drying, while the other, after resisting five dryings and re-immersions,
16th December. It was then immersed and hatched within 30 minutes,
lt.
21st. The balance dried for the second time on the 23rd, and for the third
ape unaltered after the third drying. When re-immersed on 1st November,
within 2 hours. On the 2nd November, the batch was dried for the fourth
he 12th. No eggs hatched and the batch remained in water until the 21st
the eggs and water was put into an ice chest for an hour and a half; during
vater fell from 80° F. to 73° F. 2 eggs hatched; remaining eggs dissected

on re-immersion Dried again on 24th October, and not immersed until
5 minutes, 23 within 2 hours, and 3 more the following day. On the 3rd
a third time and re-immersed on the 4th; none hatched Dried for the
gain immersed without any eggs hatching. The batch was dried for the
d until the 10th January, when all the unhatched eggs were found to have

r.
il 2nd December, when the eggs were put in a cool, heavy rain for about
ed in water; 4, 3 and 26 hatched on successive days. The batch was kept
when the piece of filter paper on which the eggs were laid was lifted from
, dry wind that was blowing; the batch was again immersed while the eggs
hour, and the remainder on the 24th December when cooled in ice chest.
ied and re-immersed; none hatched. They were again dried on 9th Nov-
opened on 12th May and found to be dead.
ed and re-immersed; none hatched. They were again dried on 9th
ggs opened on 12th May and found to be dead.
ied and exposed to rain on 2nd December; 1 hatched. Cooled on 20th
and exposing to cool, dry wind; cooled in ice chest on 24th December;
y wind action on 28th December without effect. Dried and stored 31st
he remaining eggs were found to be dead.
d; exposed to rain on 2nd December, 4 hatched. Cooled in dry wind on
n re-immersed. Again cooled in dry wind on 28th December. 2 hatched
dried and stored 31st December; all unhatched eggs collapsed during 3

ed, exposed to rain on 2nd December; 2 hatched on 3rd. Cooled in dry
he same day and 2 when cooled in ice chest on the 24th. Again cooled in
ed. Remainder dried and stored 31st December; examined 30th April,

ed and re-immersed 15th November; none hatched. On 21st November
gs was placed in an ice chest for an hour and a half; during this period the
F. All the remaining eggs hatched on the following day.
ied and re-immersed; none hatched. On the 17th November an egg was
formed larva to all appearances living, but it failed to make any movements
dry air on 20th December was without result, but after a repetition on 28th
g eggs were stored on 31st December. Remaining eggs opened 12th May

d and re-immersed a week later; 2 hatched on 4th December (this was not
uity of the conditions). Cooled in dry wind on 20th December; 1 hatched
he second cooling in dry wind on the 28th December had no effect. Remain-
cember; examined 30th April, all unhatched eggs dead.

eggs had been made in this situation it is probable that

EXPERIMENT REGARDING THE LAYING AND HATCHING OF EGGS BY *STEGOMYIA FASCIATA*, IN WHICH ONLY ONE FEMALE WAS USED

The female emerged from the 10th September, 1914. Two males were kept with her. One emerged on the 11th September, and the other on the 13th September. Opportunities for feeding on human blood were afforded each night from the 10th September onwards. The female died on the 27th October, 1914, aged 47 days. The eggs were collected each evening from the wet filter paper on which the glass jar containing the mosquitoes was inverted.

All the eggs were submerged in water. None were allowed to float.

Each batch when laid was placed in a solid watch glass and these were submerged in a large glass trough so that all the batches might have identical conditions in regard to quantity and temperature of water.

Date of Laying.	Batch No.	No. of Eggs.	Hatched.	Unhatched.	Remarks.
19 September	1	1	1		The remaining eggs were accidentally destroyed.
20 "	2	2		2	All eggs which hatched on 27th October.
21 "	3	1		1	Batches 1 to 3 were kept in a glass trough, so that all the batches might have identical conditions in regard to quantity and temperature of water. Batches 4 to 11 were kept in a glass trough, so that all the batches might have identical conditions in regard to quantity and temperature of water.
24 "	4	13	1	12	Batches 2 to 11 inclusive, were collected from the wet filter paper on which the glass jar containing the mosquitoes was inverted. Batch 2 was collected on 20th September, Batch 3 on 21st September, and Batch 4 on 24th September. Batches 5 to 11 were collected on the dates mentioned in the table. All the eggs were submerged in water. None were allowed to float.
24 "	5	26	23	3	Batch 4 was placed in a solid watch glass and these were submerged in a large glass trough so that all the batches might have identical conditions in regard to quantity and temperature of water. Batches 5 to 11 were kept in a glass trough, so that all the batches might have identical conditions in regard to quantity and temperature of water.
3 October	6	4	4		All collapsed after the 1st October.
5 "	7	35	26	9	Dried on 5th October. Batch 7 was placed in a solid watch glass and these were submerged in a large glass trough so that all the batches might have identical conditions in regard to quantity and temperature of water. Batches 8 to 11 were kept in a glass trough,

did not hatch nor collapse, it was opened, and found to contain a fully developed larva in fresh condition, probably killed in the dissection of the egg.

Experiment No. IV.

EFFECTS OF EVAPORATION AND REPLACEMENT OF WATER.

A female that emerged 23rd–24th September was left for three or four days in a cage with a number of males and then segregated. Opportunities of feeding on human blood were afforded daily. The female died on 3rd Oct. Eggs were collected each day. All the eggs were submerged when in water. Very small pans were used, containing only 10 to 15 c.c. of water.

Dates on which eggs were laid.	Number of eggs laid.	Reference number.	Date of hatching.					
			October.					November
			3	6	7	12	21	11
30th September ...	12	1	8	2	...	...	1	...
1st October ...	7	2	...	...	1	1	3	1

Remarks and Notes.

1. The water was allowed to evaporate; by the 20th October the eggs were dry. Fresh water was added, and 1 egg hatched in two hours and a half. The remaining egg collapsed while in water.

2. The water was allowed to evaporate; by the 20th October the eggs were dry and fresh water was added. 1 egg hatched within twenty minutes, 2 more within five hours. The water was again allowed to evaporate, by the 10th November the two remaining eggs were again dry; 1 collapsed, the other was re-immersed and hatched within thirty minutes.

Experiment No. I. is concerned with the laying and hatching of eggs laid by two bred females which had the companionship of several males during the course of their lives.

Experiment No. II. is concerned with the eggs laid by a single female, but two males were placed with her in order to better the chances of all the eggs laid being fertilized.

The plan of putting batches of eggs in small dishes and immersing them in one large pan of water was extended in this experiment to the whole series, with a view of getting the conditions for all the eggs as nearly identical as possible.

Experiment No. III. dealt with a batch of eggs laid by a wild female; the opportunity afforded by this find was seized on as a means of checking results obtained when eggs laid by reared captives

were used. As it turned out, the occasion was unique, but there is no reason to suppose that the eggs were in any way affected by the accident of their deposition.

Experiment No. IV. was initiated to contrast the effect of gradual evaporation of the water in which the eggs were submerged with the less natural methods employed to induce resistant eggs to hatch in Experiments No. I. and II.

The fact that 49 eggs forming batch 6 in Experiment No. I., which all hatched on the same day, were kept in a larger pan of water than batches 1 to 5 in the same experiment, raised the question of a possible relation between the size of the body of water and period of hatching.

The existence of such a relation was supported by the hatching of a large number of eggs of batch 7 (Experiment No. I.), following upon their transference to a larger dish of water. On the other hand, the addition of fresh water apart from any change in quantity was the apparent cause of batches 1, 2, 7, 8 and 10 hatching on the 29th September. A comparison with the hatching of eggs in Experiment No. II., when the quantity of water was much larger, and Experiment No. III., when it was equally large, pointed to the probability of the unanimous hatching of the eggs in batch 6 being a chance occurrence, while the partial nature of the response to either removal to larger pans or the renewal of water, together with the vagaries of hatching displayed by the batches immersed in the same pans of water in both Experiment No. I. and Experiment No. II., showed that the factors underlying hatching were probably of a complex nature.

The high percentage of apparently infertile eggs and the erratic nature of their distribution among the various batches of Experiment No. I. rendered it very doubtful if both the females had been fertilized.

It was an evident feature of all these early experiments that the incidence of hatching was dominated to a greater or lesser extent by external conditions, among which drying, the changing of water, and temperature conditions acted as *stimuli* on a certain proportion of the eggs only, wild laid eggs being affected as well as those laid in captivity.

The points raised which it seemed desirable to investigate further may be summarised in the following questions :—

(1) Does the quantity of water in which the eggs are immersed have any further influence on hatching ?

(2) Are all the eggs laid by a female capable of surviving drying; if a portion only, is the ability restricted to certain batches or evenly distributed?

(3) What is the effect on hatching of immediate as contrasted with deferred immersion; does the mortality rise in relation to the period of storage and is it affected by the humidity of the conditions of storage?

(4) Is temperature the stimulating factor which induces resistant eggs to hatch when dried and re-immersed, when they are transferred to fresh water, or when fresh water is added to that in which they are already immersed?

(5) For how long a period after impregnation is a female able to lay fertile eggs?

(6) How many females can a single male impregnate, and what percentage of the eggs of any one female will prove fertile after impregnation by a single male* ?

To these may be added a question which practically belongs to this series, but was only formulated in response to results obtained in the conduct of the experimental work above outlined :—

(7) To what extent can resistance and the tendency to defer hatching be induced by external conditions after incubation?

In order to save time, owing to the probable death of some of the insects segregated for trial, most of the experiments were started in duplicate, and in some cases bulk experiments dealing with numbers of eggs laid in the general cages were performed dealing with the same or parallel points to support the results obtained when using single females.

It will be observed that information other than that directly aimed at was obtained in some cases; such by-products are commented on when dealing with the particular experiments involved.

The experiments dealing with Questions 1, 2, 3, 4 and 7 are included in this section, while those relating to 5 and 6 are placed in that dealing with the adults. An addendum to Experiment No. XLVI. (page 123), showing the detail of the number of eggs laid by one of the females and their dates of hatching, is included with the experiment to which it belongs in the adult section, although the evidence it affords is equally applicable to this.

* The act of copulation is so rapidly and apparently frequently performed that it was not found practicable to limit the question to the result of a single pairing.

Experiment No. V.

EFFECT ON HATCHING OF SUBMERGENCE IN A SMALL OR LARGE QUANTITY OF WATER.

(*a*) Eggs Laid by a Single Female.

A female that emerged on 3rd or 4th of October was placed in a cage with a number of males. She was then segregated and afforded daily opportunities of feeding on human blood.

The eggs were collected daily and divided into two batches; these were placed in small glass dishes, one of which was submerged in a pan containing 400 c.c. of water and the other in a pan containing 4,000 c.c.

The water used was rain water that had been exposed to air and sun for a week and then strained through fine gauze.

All the eggs were kept submerged until the 8th of January, when they were dried and the sound unhatched eggs returned to the water.

Female died 22nd October.

Date of laying.	Number laid.	Number in each lot.	Reference number.	Date of hatching. October. 10	11	12	13	15	17	18	19	21	25	26	27	November. 28	29	30	31	1	3	7	9	10	12	14	18	20	22	23	24	25	30	Mortality.
7 October	62	31 small	1	16	1	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	4	1	1	6 per cent.
		31 large	2	20	5	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	...	...	...	...	3 per cent.
14 „	48	24 small	3	...	...	...	...	...	1	4	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	4	14	...	...	...	...	Nil.
		24 large	4	...	...	...	...	...	3	13	2	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	3	...	...	...	...	Nil.
22 „	70	35 small	5	...	...	...	...	...	...	...	...	...	4	6	...	4	...	...	1	...	1	1	1	1	...	...	1	3	1	6	...	...	...	14 per cent.
		35 large	6	...	...	...	...	...	...	...	...	...	10	5	1	1	1	...	...	3	2	...	...	1	1	1	...	1	8	...	...	...	...	Nil.

Remarks and Notes.

1. One egg collapsed, one that did not was returned to the water, where it eventually collapsed. 2. One egg collapsed.
3. All hatched. 4. All hatched. 5. Five collapsed. 6. All hatched.

Experiment No. VI.

EFFECT ON HATCHING OF SUBMERGENCE IN A SMALL OR LARGE QUANTITY OF WATER.

(a) Eggs Laid by a Single Female.

A female that emerged on 4th or 5th October was kept in a cage with several males for two or three days; she was then segregated and given daily opportunities of feeding on human blood.

The eggs were collected each day and divided into two lots, which were placed in separate glass dishes. These were then submerged in the same pans as those used for Experiment No. V.

All the eggs were kept submerged until 8th January. When they were dried, the single unhatched egg of Lot 1 did not collapse and was returned to the water.

Date of laying.	Number laid.	Numbers in each lot.	Reference number.	Date of hatching.														Viability.
				October.							November.							
				12	14	15	16	17	20	28	3	13	20	22	23	24	30	
9 October ...	14	7 (small)	1	1	...	...	...	...	...	1	...	...	...	2	1	1	...	14 per cent.
		7 (large)	2	...	...	...	...	...	3	...	...	1	...	3	...	...	...	Nil.
10 ,, ...	45	22 (small)	3	...	4	1	...	...	...	...	...	...	1	13	...	2	1	Nil.
		23 (large)	4	...	2	1	2	1	...	1	3	...	10	3	...	...	...	Nil.

Remarks and Notes.

1. The remaining egg subsequently collapsed.

The female disappeared out of jar on the 12th October. (Either eaten by ants or escaped, owing to some meddlesome person lifting the jar.)

Experiment No. VII.

EFFECT ON HATCHING OF SUBMERGENCE IN A SMALL OR LARGE QUANTITY OF WATER.

(*b*) Eggs laid by more than one Female.

The batch of 192 eggs used for this experiment were laid in a cage containing a number of *S. fasciata* of both sexes. All the eggs were laid on the same night.

*The eggs were placed in small floating docks with a silk gauze bottom and allowed to sink or float as chance determined.

The water used was rain water that had been exposed to sun and air for a week and then strained through fine gauze.

Lot *A*, consisting of 94 of the above batch of eggs, was placed in a single dock floating in a small pan containing 100 cc. of water.

Lot *B*, consisting of 98 of the above batch of eggs, was distributed over 4 docks floating in a large pan containing 4,000 cc. of water.

Lot and number of eggs.	Date of hatching.											
	October.								November.			
	22	23	24	25	26	27	29	30	1	2	9	14
A. (small pan) 94 eggs ...	11	27	15	...	9	6	3	4	6	6	1	...
B. (large pan 98 eggs ...	3	29	40	10	1	...	...	...	...	...	...	1

A. Total hatched at 30th November, $\underline{88} = 94$ per cent.

B. „ „ „ „ $\underline{84} = 86$ „

This experiment had to be abandoned at the end of November as a wild female got through the mosquito netting cover of the pan containing Lot *B* and oviposited in one of the docks.

* This method was adopted in order to avoid the expenditure of the time required to sink so large a number of eggs, and also because of the essential difficulties of proving hatching if the eggs were simply allowed to scatter in a large pan. For full details of the method see description on page 178 and illustrations Plate 29 and Figure 27.

Experiment No. VIII.

EFFECT ON HATCHING OF SUBMERGENCE IN A SMALL OR LARGE QUANTITY OF WATER.

(*b*) Eggs laid by more than one female.

The 400 eggs used in this experiment were laid in a cage containing a number of both sexes.

The period during which the eggs were laid covered forty-eight hours.

The eggs were placed in floating docks.

The water used was from the pipe service at Freetown.

Lot *A*, consisting of 200 eggs, were placed in a single dock floating in a small pan containing 100 cc. of water.

Lot *B*, consisting of 200 eggs, were distributed in two docks floating in a large pan containing 4,000 cc. of water.

Lot and number of eggs.	Date of Hatching.																																	
	October.								November.																			December.	January.		February.		March.
	24	25	26	27	28	29	30	31	1	5	6	7	8	9	*10	11	12	13	14	15	16	17	20	22	23	27	28	10	24	28	11	16	18	5
A small pan, 200 eggs ...	11	40	12	...	...	1	3	...	...	2	...	1	...	1	36	6	3	1	...	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...
B large pan, 200 eggs ...	1	10	45	3	2	1	8	1	7	4	4	3	1	2	5	7	2	8	2	8	14	2	1	2	4	2	2	1	1	2	2	1	1	1

A. Total hatched, 130. Mortality, 35 per cent.

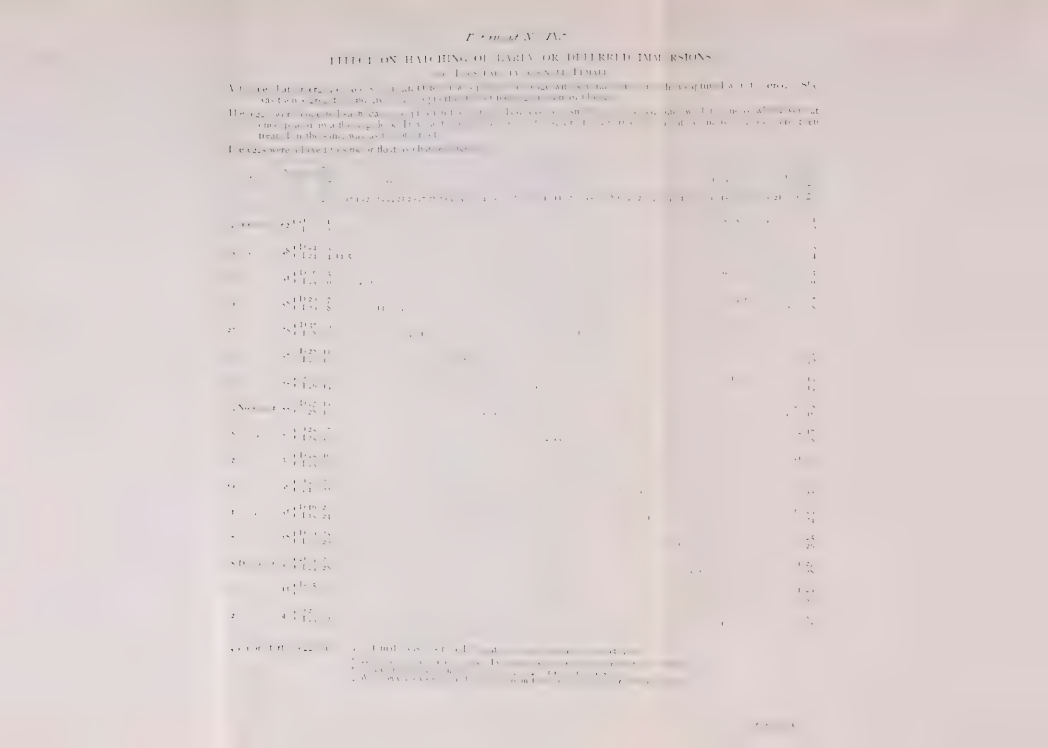
B. „ „ 160. „ 20 „

* The morning of the 10th November was cooler than on the two previous days (80 F. on 8th, 78 F. on 9th, 76° F. on 10th). It is possible that this may have had some effect on the smaller quantity of water in lowering the temperature which was not operative in the large pan. It must be mentioned, however, that no similar occurrence was observed in the pans containing eggs of batches belonging to other experiments.

Experiments Nos. V., VI., VII. and VIII. afford no very decisive answer to the first question. The most it is possible to say is that within the limits of the experiment the smaller quantity of water raised the percentage of mortality and was possibly responsible for some delay in hatching in Experiments Nos. V., VI. and VII., while Experiment No. VIII. tends to obscure the issue on this point. A very interesting fact clearly brought out by the series is, however, the length of the period which may elapse between the immersion of the egg and its hatching even when no dry period intervenes. In the Experiments No. V. and No. VI. periods of 40 to 50 days are shown, while in Experiment No. VIII. a few of the eggs waited 4 or 5 months before hatching.

EFFECT ON HATCHING OF EARLY OR DELAYED IMMERSIONS

by Lee Lai-yung and S. H. Tsimis



Immediately Immersed Lots.

Some of the apparent mortality or infertility among the immediately immersed eggs must be attributed to the method employed of allowing them to either sink or swim in floating docks. While convenient in many ways for observation and effecting a very large saving in time and labour, this system is not without its drawbacks. Chief among these there is the fact that, after a few weeks' immersion it becomes impossible to follow up all the eggs individually, owing to the wood and gauze forming the docks becoming discoloured, while some of the eggs get washed into crevices at the junction of the wood and gauze.

The rusting of the tins used (in the absence of glass pans) was the cause of much discolouration. There may also have been a few actual losses owing to the gauze bottom of the docks rotting or fraying through with the lapse of time.

The docks containing the immediately immersed lots were taken from the water and dried in sequence between the 10th November and the 7th January in order to make room for those containing the later lots—the same water being used throughout. They were subsequently returned to the water, but it will be noted that only in the case of Lots Nos. 8 and 16 did eggs hatch after re-immersion.

Lots in which Immersion was Deferred.

No. 1. 5 eggs showed signs of collapse within three days of drying.
No. 3. 3 „ „ „ „ „ „ „
No. 5. 2 „ „ „ „ „ „ „
No. 7. 2 „ „ „ „ „ „ „
No. 9. (No record).
No. 11. 4 eggs showed signs of collapse within three days of drying.
No. 13. 4 „ „ „ „ „ „ „
No. 15. 5 „ „ „ „ „ „ „
No. 17. 4 „ „ „ „ „ „ „
No. 19.
No. 21.
No. 23.
No. 25. (No record).
No. 27.
No. 29.
No. 31.

On the 14th December, Lots Nos. 1, 3, 5, 7, 9, 11, and 13 were examined :—

No. 1. 31 eggs present ; 5 collapsed.
No. 3. 24 „ „ ; 4 „
No. 5. 16 „ „ ; 2 „
No. 7. 29 „ „ only partially examined ; 23 were full.
No. 9. 36 „ „ „ „ „ ; no collapsed seen.
No. 11. 28 „ „ ; 8 collapsed.
No. 13. 26 „ „ ; 4 „

All these seven lots were placed in floating docks on the 14th December.

On the 19th January Lots Nos. 15, 17, 19, 21, 23, 25, 27 and 29 were examined :—

No. 15.	26	eggs	present ;	all	but	15	more	or	less	collapsed.
No. 17.	8	,,	,,	,,	,,	4	,,	,,	,,	
No. 19.	15	,,	,,	,,	,,	6	,,	,,	,,	
No. 21.	14	,,	,,	,,	,,	5	,,	,,	,,	
No. 23.	16	,,	,,	,,	,,	13	,,	,,	,,	
No. 25.	9	,,	,,	,,	,,	1	,,	,,	,,	
No. 27.	4	,,	,,	,,	,,	2	,,	,,	,,	
No. 29.	5	,,	,,	,,	,,	2	,,	,,	,,	

All these eight lots were placed in floating docks on the 19th January.

Unfortunately, the term "collapsed" was applied, during the early course of the experiment, to all eggs that showed marked signs of shrinkage, it being at that time considered that this was a certain forerunner of complete collapse, and that such eggs were infertile. Subsequent experience proved that this was not necessarily the case, as it was observed that partially collapsed eggs, when wetted may either hatch at once or recover their full rotundity and hatch later on.

The loss in numbers of Lots Nos. 17, 21, and 23 can only be accounted for on the assumption that they had been destroyed and eaten by *Psocidæ*, which had managed to get through the close fitting lids of the boxes in which the eggs were kept. These enemies had only penetrated into the boxes in which these three lots were kept.

FEEDING (ON BLOOD) AND EGG-LAYING OF *STEGOMYIA FASCIATA*.

Record of female used in Experiment No. IX.

Date of feeding and egg-laying.	Number of eggs laid.	Remarks *re* feeding.
12 October ...	62	Did not feed.
13 ,, ...	48	Fed.
14 ,, ...	...	,,
16 ,, ...	31	,,
19 ,, ...	59	,,
20 ,, ...	...	,,
23 ,, ...	75	,,
24 ,, ...	...	,,
26 ,, ...	55	,,
27 ,, ...	2	,,
28 ,, ...	...	,,
29 ,, ...	.	,,
30 ,, ...	52	,,
31 ,, ...	...	,,
1 November...	...	,,
2 ,, ...	7	Did not feed.
3 ,, ...	48	,, ,,
4 ,, ...	3	,, ,,
5 ,, ...	...	Fed.
6 ,, ...	...	Fed slightly.
8 ,, ...	47	Fed.
9 ,, ...	...	,,
11 ,, ...	2	Did not feed.
12 ,, ...	28	Fed.
16 ,, ...	39	,,
17 November...	...	Fed.
18 ,, ...	...	,,
20 ,, ...	...	,,
21 ,, ...	31	,,
26 ,, ...	7	,,
27 ,, ...	11	Did not feed.
28 ,, ...	...	Fed slightly.
1 December...	...	Fed.
3 ,, ...	...	,,
4 ,, ...	...	Bit, drew very little (if any) blood.
8 ,, ...	47	Fed.
9 December...	1	,,
10 ,, ...	11	,,
12 ,, ...	46	,,
14 ,, ...	...	Bit.
18 ,, ...	32	Fed.
19 ,, ...	...	Fed slightly.
22 ,, ...	...	,, ,,
23 ,, ...	3	Did not feed.

As only infertile eggs were being laid, a male was put in jar with the female.

Record of female used in Experiment No. IX.—continued.

Date of feeding and egg-laying.	Number of eggs laid.	Remarks *re* feeding.
24 December ...	1	Fed slightly.
25 ,, ...	...	,, ,,
26 ,, ...	...	Bit.
27 ,, ...	20	Fed.
28 ,, ...	...	,,
29 ,, ...	2	Bit.
30 ,, ...	...	Fed.
1 January ...	5	Bit.
2 ,, ...	...	,,
3 ,, ...	3	Fed slightly.
4 ,, ...	4	,, ,,
5 ,, ...	...	Fed.
6 ,, ...	...	Fed slightly.
7 January ...	7	Did not feed.
9 ,, ...	...	...
As the male added on the 23rd December had died two fresh ones were added.		
10 January ...	...	Fed heavily.
11 ,, ...	16	...
The female disappeared although both the males remained in the jar. I can only account for this by supposing that ants found their way in and carried off the female piecemeal.		

10- to 15-minute opportunities of feeding on blood were afforded every night, but the dates on which egg-laying or feeding took place alone are recorded.

The last fertile egg was laid on the 12th December—63 days after separation from the males; at this time 712 eggs had been laid in 22 days. Allowing that eggs, when laid on following days, belong to the same batch (using this term to mean the ripe contents of the ovaries), this gives 15 batches of eggs within the fertile period.

The total number of eggs laid was 798, the last 87 being divided into 6 separate batches laid with intervals of more than a day between them.

The males introduced on the 23rd December and 9th January did not effect the fertilization of the eggs laid subsequently. During the period the males were with her, the female had the choice of feeding on honey as well as blood.

There is little doubt but that ants were responsible for the disappearance, as occasions in which legs, wings and other remains were left behind, as well as one instance when they were caught in the act, occurred during the course of the experiments. At the same time, I am disposed to consider that the female was nearly, if not quite, spent. It is possible, however, that if a chance of pairing had been given to her late in November, when signs of waning fertility at first began to show, that many of the late laid eggs might have proved fertile.

The evidence afforded by this experiment is, in a general sense, a sufficiently clear answer in the affirmative to Question (2), and the second portion of the question therefore falls.

In utilizing the evidence afforded by this experiment relating to the effect of immediate or deferred immersion (Question (3)), some preliminary precautions are necessary. Lots 17, 21 and 23 should be left out of account, as the ravages of book lice among the stored eggs not only reduced the numbers, but very probably, as their habit

is, perforated others and killed the larvæ, leaving the shells intact. It will be better also to exclude all the batches subsequent to 26, as the general infertility of the December-laid eggs is very obvious.

Taking Lots 1 to 16, 19/20 and 25/26, we find that of the immersed eggs 199, = 82 per cent., hatched out of 244, while of those stored dry for a month or more before immersion 173 = 72 per cent., hatched out of 242, the period of dry storage being apparently responsible for 10 per cent. mortality.

Two batches, however, laid on the 19th and 23rd of October, require special attention in this connection. The eggs were deposited on wet wood (fragments of willow chip boxes) in place of the usual filter paper. It will be observed that the percentage hatching in these batches is high, 86 per cent. and 91 per cent., while they afford the only instance in which the stored eggs show a lower mortality than the portion of batch immersed immediately after laying. From this it would appear that the material on which the eggs rest may be a factor in their survival during periods of drought, a conclusion which fits in with the facts already noted in the introductory remarks (*see* page 19) regarding the recovery of shape by shrunken eggs.

*Experiment No. X.**

EFFECT ON HATCHING OF EARLY OR DEFERRED IMMERSION.

(*b*) Eggs laid by more than one Female.

144 eggs were laid on the night of the 8th–9th October on filter paper in a cage containing numbers of *S. fasciata* of both sexes.

These were divided into two lots—*A*, 66 eggs, which were immersed on the 9th October, and *B*, 78 eggs, which were allowed to slowly dry and then stored in the animal house until the 17th November, when they were immersed, 39 days after laying.

*In this and the following experiments, as well as in other cases where eggs were stored dry, woodlice and small insects, such as ants and *Psocidæ*, easily gained entrance to the eggs in paper envelopes, and, with the exception of the larger woodlice, to the wire gauze tubes as well. *Psocidæ* even penetrated into entomological boxes unless the lids fitted very tightly.

The surface of the filter paper on which the eggs were laid was often gnawed off in patches and numbers of eggs had disappeared. No evidence that either ants or woodlice intentionally destroy eggs was obtained, but, on the other hand, there is definite proof that *Psocidæ* do so. See account under "Enemies," page 59, Experiment No. XXII.

LOT *A*.

66 eggs laid on the night,	DATE OF HATCHING. OCTOBER. 12	13	14	18	19	20	NUMBER OF EGGS WHICH HATCHED AFTER STORAGE.	PERCENTAGE.
8—9 October ...	3	20	11	1	2	1	38	57

On the 7th November, after 29 days' immersion, Lot *A* was taken from the water and stored dry in the Laboratory until the 22nd January (76 days). An examination showed 3 full and 16 shrunken eggs, the remainder having collapsed; the eggs were then transferred to the mosquito house and placed under shelter. They were finally immersed on the 29th April after 173 days' storage without water. None hatched, and dissection showed that all the unhatched eggs were dead.

LOT *B*.

Was examined on the 17th November after 39 days' storage; 9 of the eggs had collapsed. The lot was then immersed in water. After 3 days none of the eggs having hatched, the pan was placed in the ice chest, the temperature of the water falling within 2 hours from 81° F. to 73° F.; 7 eggs hatched while in the ice chest. The pan was then kept at Laboratory temperature until the 4th January.

78 eggs laid on the night,	DATE OF HATCHING. NOVEMBER. 20	22	23	DECEMBER. 21	NUMBER OF EGGS WHICH HATCHED AFTER STORAGE.	PERCENTAGE.
8—9 October ...	7	28	6	1	42	54

On the 4th January, after 48 days' immersion, the lot was removed from the water, dried, and stored in the mosquito house under cover until the 29th of April, when it was again immersed. None of the eggs hatched, and dissection proved that all were dead.

Experiment No. XI.

EFFECT ON HATCHING OF EARLY OR DEFERRED IMMERSION.

(*b*) EGGS LAID BY MORE THAN ONE FEMALE.

493 eggs were laid between the 10th–14th October on filter paper in a cage containing numbers of *S. fasciata* of both sexes. These were divided into two lots—*A*, 197 eggs, which were immersed on the 14th October, and *B*, 196 eggs, which were slowly dried and then stored in the animal house until the 4th January, they were then immersed 82 days after laying.

LOT *A*.

	Date of hatching. October.						Number of eggs which hatched prior to storage.	Per-centage.
	14	15	16	17	18	20		
197 eggs laid 10—14 October ...	30	28	61	5	9	4	137	70

On the 7th November, after 24 days' immersion, Lot *A* was taken from the water and stored dry in the laboratory until the 22nd January (76 days). An examination showed 8 full and 24 shrunken unhatched eggs, the balance having collapsed ; the eggs were then transferred to the mosquito house and placed under shelter. They were finally immersed on the 29th April after 173 days' storage. After 14 days' immersion, during which period they were twice cooled, the unhatched eggs were dissected. *One living larva* was extracted, the remainder were dead.

LOT *B*.

Was examined on the 4th January after 82 days ; very many of the eggs were shrunken or collapsed. They were first put into a saturated atmosphere, and after 24 hours wetted by sprinkling and finally immersed ; 4 hatched within 2 hours.

	Date of hatching. January.									Number of eggs which hatched after storage.	Per-centage.
	4	5	6	7	10	14	15	16	17		
196 eggs laid 10—14 October. Immersed 4 January	4	17	1	2	1	3	18	3	2	51	26

They were dried on the 26th January and stored in the mosquito house, under shelter, until the 29th April, and were then again immersed after 93 days' storage. None of the eggs hatched, and dissection proved them to be all dead.

Experiment No. XII.

EFFECT ON HATCHING OF EARLY OR DEFERRED IMMERSION.

(*b*) EGGS LAID BY MORE THAN ONE FEMALE.

517 eggs were laid between the 14th–16th October on filter paper in a cage containing numbers of *S. fasciata* of both sexes. These were divided into two lots, *A*, 254 eggs, which were immersed on the 16th October, and *B*,

263 eggs, which were dried, placed in a wire gauze tube and suspended in the covered pit in the mosquito house until the 18th November, 33 days after laying.

Lot *A*.

	Date of hatching. October.					Number of eggs which hatched prior to storage.	Per-centage.
	17	18	19	20	21		
254 eggs laid 14 – 16 October	70	87	27	17	1	202	80

On the 7th November, after 22 days' immersion, Lot *A* was dried and then stored in the Laboratory until the 22nd January (76 days). An examination showed 22 full and 22 shrunken unhatched eggs, the balance having collapsed: the eggs were transferred to the mosquito house and stored under shelter. They were then immersed again on the 29th April after 173 days' storage. *One hatched* on the 6th May and *one* on the 12th, both in response to cooling; but the larvæ died within a few hours of hatching. The remaining unhatched eggs were dissected; 2 were found to contain living larvæ, the remainder were dead.

Lot *B*.

Was examined on 18th November; it was found that the paper cover to the wire gauze tube was saturated with moisture, while the filter paper on which the eggs were laid was damp. 20 eggs had hatched owing to drops of water precipitated on the wire gauze having flooded single eggs or small groups of eggs; 13 eggs had collapsed; the remainder were immersed 33 days after laying.

	Date of hatching. November.						December.				Number of eggs which hatched after storage.	Percentage of unhatched eggs at date of immersion.
	18	20	22	23	24	29	4	9	12	18		
Survivors of 263 eggs laid 14–16 October	35	15	82	19	6	3	1	1	1	1	164	68

A few of the eggs hatched within 3 minutes of their immersion, 18 larvæ were out within one hour and 35 within three hours. None hatched on the 19th. On the 20th November the pan was placed in the ice chest; in two hours the temperature of the water fell from 80° F. to 73° F., 15 hatched; the pan was then kept at Laboratory temperature until 3rd December, when it was placed in an incubator at 97° F. for two hours. Owing to an accident 18 unhatched eggs were lost. On the 4th January Lot *B* was dried and stored under shelter in the mosquito house until 29th April, when it was again immersed. No larvæ emerged, and dissection showed that all the unhatched eggs were dead.

Experiment No. XIII.

EFFECT ON HATCHING OF EARLY OR DEFERRED IMMERSION.

(*b*) Eggs laid by more than one Female.

580 eggs were laid between the 16th and 19th October, on filter paper, in a cage containing numbers of *Stegomyia fasciata* of both sexes. These were divided into two lots, *A*, 275 eggs, which were immersed on the 19th October, and *B*, 305 eggs, which were dried, placed in a wire gauze tube, wrapped in paper, and placed under dead leaves in the mosquito house.

Lot *A*.

	Date of hatching.									Number of eggs which hatched prior to storage.	Per-centage.
	October.					November.					
	19	20	21	22	23	2	3	4	6		
275 eggs laid 16—19 October.	16	92	47	18	26	1	1	1	4	206	75

On the 17th November, after 19 days' immersion, Lot *A* was dried and stored in the Laboratory until the 22nd January (76 days). An examination showed 13 full and 16 shrunken eggs—the remainder of the unhatched eggs having collapsed. The eggs were transferred to the mosquito house and stored under shelter till the 29th April, when they were again immersed after 173 days' storage.

On the 2nd May, 1 hatched and died shortly after emerging.
„ „ 4th May, 3 „ one of which died.
„ „ 6th May, 1 „ 199 days after laying.
Dissection showed the remaining eggs to be dead.

Lot *B*.

Was examined on the 9th March, after 141 days' storage; the paper covering of the tube had been mostly eaten off—woodlice and millipedes were present on the outside of the tube, ants and *Psocidæ* in the interior. One of the four slips on which the eggs had been laid was taken out, the tube was recovered with paper and replaced under the leaves. Only 27 eggs were found on the slip in place of the 50 originally laid on it. Of these by far the larger number had already hatched, probably during heavy and prolonged rain in November or December; 2 eggs were full, 18 had hatched, and 7 had collapsed more or less completely. This portion of Lot *B* was immersed on the 9th of March and on two occasions between this date and the 20th of the same month, the paper with the eggs on it was lifted and cooled by exposure to draught.

1 hatched on the 20th—152 days after laying; a male was bred.
1 „ „ 24th—this larva died shortly after emergence.
1 „ „ 30th—this larva was dead when found.
All the remainder proved to be dead when opened.

On the 21st April, after 6 months' storage, the remaining 3 slips of Lot *B* were examined and then immersed :—

4 hatched when cooled on 23rd April, 186 days after laying.
1 „ „ „ for the second time, on the 27th April, and died shortly after emerging.
1 hatched when cooled for the third time, on the 12th May, 205 days after laying.

Of the 305 eggs stored, 27 were found on the slip taken out on the 9th March, and 122 on the 3 slips examined on the 21st April ; in all 149 eggs. Of these, 43 had more or less completely collapsed ; 9 retained their shape and 97 had hatched while stored. 9 eggs hatched.

These experiments (Experiments X. to XIII.), while affording interesting general information relating to Question (3), fail to give a decisive answer to that portion of it which concerns a possible proportional relation between mortality and period of storage. This is due to the destruction by *Psocidæ* (book lice) of large numbers of the stored eggs in some of the experiments, and sufficiently numerous attacks in the case of others to throw doubt on the validity of the results. Such a heavy reduction of numbers was not foreseen, and in any case would have been difficult to guard against without entirely militating against natural conditions, as it would have been necessary to enclose the eggs in tubes or boxes with all but air-tight lids. Unfortunately, the cause of the reduction was not recognised until a late stage of the work, otherwise a careful examination of the stored eggs in Experiments Nos. X. and XI. might have allowed of some definite proportional results being arrived at. The excess in mortality, after 39 days' storage, of Lot *B* in Experiment No. X., is only 3 per cent., which, in view of the foregoing explanation, is probably devoid of significance.

In Experiment No. XI. the excess in mortality amounts to 40 per cent., which may be partly attributable to the lengthened period of storage, but in any case a very considerable allowance must be made for the destruction of eggs by these small enemies.

Experiment No. XII. was designed to contrast with No. X., the stored eggs being kept under very humid conditions. If allowance be made for a difference in the constitution of the eggs used, as shown by the different percentages which hatched of the unstored eggs in the two experiments, it would appear that storage under humid conditions, for the short period involved, affords no advantage.

Experiment No. XIII. Although such an extensive destruction of the stored eggs was disappointing, still a larger wastage than in the other experiments was to be expected, both on account of the longer period of time involved and also because the conditions of

storage rendered the eggs not only more liable to the attacks of other insects but to be washed away by heavy rains as well. The reduced numbers are so small that but little reliance can be placed on any conclusion concerning these hatchings, more especially as it is uncertain to what extent the collapsing resulted from the attacks of book lice or from natural causes. If only the apparently sound eggs are considered, the result shows that 6 eggs out of 9 hatched (or 66 per cent.). This is probably far too high for a general survival rate under the conditions in the light of general experience, as apart from actual experiment, which suggests that long storage is certainly responsible for an increased mortality, apart from the attacks of enemies.

The Effect of Changes of Temperature.

The possibility of changes of temperature affecting the hatching of eggs was recognised at an early stage of the research. The preliminary trials which formed the basis for Question (4) suggested that a rapid fall of a few degrees Fahr. acted as a stimulus to induce the hatching of resting or resistant eggs, whereas an equivalent rise had little, if any, influence

The following experiments were then carried out, two plans being employed. In the first, which relates to cold only, eggs of many different stocks and layings which proved to be resistant under previous long continued immersion or repeated dryings and wettings, were cooled by one or other of the following methods:—

(1) By exposing the dry eggs to rain on a cool day.

(2) By placing the pans of water in which the eggs were immersed in an ice chest.

(3) By lifting the filter paper on which the eggs were lying from the pan of water and exposing it to rapid evaporation in a strong draught of dry air.

It is to be noted that in (2) and (3) the eggs had been kept immersed for several days before the trial, so that the larvæ had had opportunity of emerging right up to the time of the test. On the other hand, in method (1) the eggs, though already proved to be resistant, had been kept dry for a longer or shorter time before the trial.

In the second plan a large batch of eggs laid between the 23rd November and 7th December in a cage containing a number of *S. fasciata* was employed. One portion was stored dry while the other was immersed until all the eggs ready to hatch had done so.

The resistant eggs, which did not respond within a period of 17 days' immersion, were divided, one portion being submitted to a rapid rise of temperature by placing the pan containing them in an

incubator at 95° F., while the pan containing the other portion was transferred to the ice chest.

The subsequent history of all the eggs that proved resistant to these conditions was, so far as possible, followed up.

Experiment No. XIV.

EFFECT OF COOLING ON RESISTANT EGGS OF VARIOUS BATCHES.

(1) By placing in rain on a cool, wet day (2nd December, 1914).

After remaining in the rain for about thirty minutes the eggs were placed in rain water and left out of doors for an hour. (The fall of the dry bulb of the hygrometer was less marked than that of the wet bulb on the 2nd December, 1914).

Reference to source from which the eggs were taken.	Date when the eggs were laid.	Number of eggs in the original batch as laid.	Number which hatched within 4 hours.	Number which hatched within 20 hours.	Notes regarding the previous history of the resistant eggs or the batches of which they formed part.
S. fasciata : —					
Exp. No. II., No. 7	5 Oct.	37	4	3	This batch of eggs had been immersed for 34 days before drying, but none of the eggs hatched.
Exp. No. II., No. 10	12 ,,	4	1	...	Immersed for 27 days before drying. No larvæ had emerged.
Exp. No. II., No. 11	13 ,,	18	4	...	Immersed for 26 days before drying. Only 1 larva had emerged.
Exp. No. II., No. 12	14 ,,	31	2	...	Immersed for 25 days before drying. No larvæ had emerged.
From Fertility Experiment : —					
B. II.	3 Nov.	35	4	...	Only 4 larvæ emerged during the period of immersion after laying, the resistant eggs had been dried and immersed several times without effect.
B. III.... ...	2 ,,	84	5	...	47 larvæ emerged within 4 days of laying; the resistant eggs had been dried and re-immersed on several occasions without effect.
B. III.... ...	5 ,,	80	1	...	65 larvæ emerged within 4 days of laying, and the resistant eggs had been dried and immersed several times without effect.
B IV.... ...	11 ,,	28	3	...	13 larvæ emerged within 4 days of laying, and the resistant eggs had been dried and re-immersed 3 or 4 times without effect.
C. I.	7 ,,	30	1	...	3 larvæ emerged within 6 days of laying; the resistant eggs had been dried and re-immersed several times without effect.
C. VII. ...	13 ,,	16	5	...	No larvæ had emerged within 10 days of laying, and the whole batch had been dried and re-immersed 3 or 4 times without result.

Experiment No. XV.

EFFECT OF COOLING ON RESISTANT EGGS OF VARIOUS BATCHES.

(2) By placing the pans of water in which the eggs were immersed in an ice chest.

Fall of Temperature from 81° F. to 73° F. Time in ice chest, about 2 hours.

Reference to source from which the eggs were taken.	Date when eggs were laid.	Number of eggs in the original batch as laid.	Number which hatched within 3 hours.	Number which hatched within 20 hours.	Number which hatched within 44 hours.	Notes with regard to the previous history of the resistant eggs submitted to the test.
S. sugens ...	27 Oct.	20	3	...	...	After several wettings and dryings had remained immersed for 6 days without any hatching.
S. fasciata :—						
Exp. No. X. ...	8/9 Oct.	70	7	...	28	The whole batch had been kept dry for 39 days before it was immersed. None of the eggs hatched in the 3 days that elapsed between immersion and cooling.
Exp. No. XII.	13/14 Oct.	263	15	...	82	The whole batch was kept dry for 33 days before its immersion. 35 larvæ emerged within 3 hours of the eggs being placed in water, but none hatched on the following day. On the third day after immersion the water was cooled.
Exp. No. II., No. 4	24 Sept.	32	2	...	...	After 4 periods of drying and wetting which followed the first immersion the resistant eggs had been immersed for several days prior to cooling.
Exp. No. II., No. 13	18 Oct.	18	...	...	...	After the first period of immersion the resistant eggs were dried; they had been again immersed for several days before cooling took place. *No effect.*
From Fertility Experiment :—						
B. III.	14 Nov.	84	...	...	...	Batch was immersed for first time on 18th Nov. when 27 hatched; on the 19th 31 hatched; none on the 20th; cooled on 21st. *No effect.*
B. IV.	8 Nov.	5	...	1	...	Immersed for 4 days prior to cooling.
C. I.	10 Nov.	31	6	2	...	,, 6 ,, ,,
C. I.	13 Nov.	18	1	...	...	,, 4 ,, ,,
C. I.	16 Nov.	37	...	1	...	,, 1 ,, ,,
C. IV.	13 Nov.	45	8	10	...	,, 4 ,, ,,
C. V.	15 Nov.	28	...	2	...	,, 1 ,, ,,

Experiment No. XVI.

EFFECT OF COOLING ON RESISTANT EGGS OF VARIOUS BATCHES.

(3) By lifting the filter paper on which the eggs were lying from the water and exposing to a strong draught when the harmattan was blowing (28th December), the eggs being re-immersed in the same water before they were dry.

Reference to source from which the eggs were taken.	Date when the eggs were laid.	Number of eggs in the original batch as laid.	Number which hatched within 1 hour.	Notes relating to the previous history of the eggs used.
S. fasciata :—				
Exp. No. II., No. 4	24 Sept.	32	...	Used in Cooling Experiment, No. XV.
,, No. 10	12 Oct.	4	...	,, ,, ,, No. XIV.
,, No. 11	13 ,,	18	2	,, ,, ,, No. XIV.
,, No. 12	14 ,,	31	1	,, ,, ,, No. XIV.
,, No. 14	19 ,,	16	1	A resistant batch, see notes to Exp. No. II., No. 14.
,, No. 15	21 ,,	23	...	A resistant batch, see notes to Exp. No. II., No. 15.
From Fertility Experiment :—				
A. II.	27 Oct.	9	2	Resisted long immersion and several dryings.
B. II.	3 Nov.	35	...	Used in Cooling Experiment, No. XIV.
B. III.	5 ,,	80	...	,, ,, ,, ,,
B. III.	2 ,,	84	...	,, ,, ,, ,,
B. IV.	11 ,,	28	1	,, ,, ,, ,,
C. I.	7 ,,	30	,,	,, ,, ,, ,,
C. I.	29 ,,	21	1	Resisted a long period of immersion.
C. I.	3 Dec.	23	...	Resisted long immersion; 2 hatched when cooled on 24th December.
C. VII.	13 Nov.	16	2	Used in Cooling Experiment No. XIV.
C XIX.... ...	3 Dec.	47	1	Resisted 20 days' immersion.

Experiment No. XVII.

EFFECT OF CHANGES OF TEMPERATURE ON THE HATCHING OF EGGS OF *STEGOMYIA FASCIATA*.

The eggs used were laid on wet filter paper in a cage containing numbers of adults, between the dates 23rd November and the 7th December. The batch contained approximately 1,300 eggs*. About 600 of these (Lot *B*) were dried and stored dry from the 7th December until 24th March (107) days. The other portion (Lot *A*), about 700 eggs, were at once immersed in water without the filter paper on which they were laid being allowed to dry.

138 eggs (about 20 per cent.) hatched between 7th December and the 13th; the batch was, however, kept immersed until the 24th December, although no more larvæ emerged.

DETAILS OF HATCHING.

LOT *A*.	DECEMBER.							NUMBER OF EGGS WHICH HATCHED.	PERCENTAGE.
	7	8	9	10	11	12	13		
About 700 eggs laid 23rd November to 7th December...	8	69	42	11	3	4	1	138	about 20

Lot *A* was then divided into two portions: *A*1, containing about 420 eggs and shells; *A*2, containing about 250. *A*1 was placed in a pan with a portion of the water in which they had been immersed since the commencement of the experiment, and placed in an ice chest for 90 minutes—the temperature of the water falling from 80° F. to 74° F. The smaller lot, *A*2, was treated similarly as regards transfer, but the pan was placed in an incubator for the same period of time—the temperature of the water rising from 80° F. to 95° F. Eggs hatched as under:—

A1† "Cooled," within $1\frac{1}{2}$ hours	102	
,, $2\frac{1}{2}$,, when the temperature had risen again to 80° F. ...	4	
,, $3\frac{1}{2}$,, ...	1	
,, 24 ,, ...	0	
Total ...	107	= about 25 per cent.

* The difficulties of counting large numbers of these small eggs is considerable. Laid in scattered but closely approximating groups, the individual eggs are often in contact; accuracy in counting was only possible at an expenditure of time which was not available without sacrifice in other directions.

† 12 larvæ from each Lot, *A*1 and *A*2, were reared under precisely similar conditions:—
Of the "Heated," 7 attained maturity; mortality 41 per cent.
,, "Cooled," 11 ,, ,, ; ,, 8 ,,

*A2** "Heated" within $1\frac{1}{2}$ hours			2
,, $2\frac{1}{2}$,, when the temperature had again fallen to 80° F.			6
,, $3\frac{1}{2}$,, ...			26
,, 24 ,, ...			6
Total ...			40 = about 16 per cent.

On the day following the first test, both pans were put into the ice chest for $2\frac{1}{2}$ hours; the temperature of the water fell from 80° F. to 73° F.; eggs hatched as follows :—

A1 "Cooled," within $2\frac{1}{2}$ hours	2
2 days after	1
	3
A2 "Heated," within $2\frac{1}{2}$ hours	13
5 days after	1
7 days after	1
	15

Adding these figures to those previously obtained, we find that 104 resistant eggs hatched in response to cooling—about 25 per cent. of the original Lot *A1*; of those submitted to heat only two actually emerged in response to the rise of temperature, about 1 per cent. of the original Lot *A2*, but that 53 hatched in response to falls of temperature subsequent to heating—about 21 per cent. This would seem to indicate that the temperatures employed had little, if any, effect, the actual stimulus being in both cases cooling in relation to the previous condition.

On the 4th January Lots *A1* and *A2* were lifted from the water and stored dry with Lot *B* until the 24th March (79 days). An examination of all three lots on that date showed that the number of eggs or shells in each lot had been reduced by 10 to 15 per cent., either owing to eggs becoming detached from the paper on which they were laid or, as I think, from the depredations of *Psocidæ*.

The three lots were immersed in separate pans on the 24th March, cooling in an ice chest being resorted to as opportunity occurred. The dates on which cooling took place are indicated by an asterisk. The fall in temperature of the water, which placing in the ice chest caused, was generally about 6° or 8° F.

On the 19th April the experiment had to be closed, owing to an accident.

At this point the influence of cooling is, however, sufficiently obvious for all practical purposes, although its effect differs in detail as regards Batch *A* (1 and 2) on the one hand, and Batch *B* on the other, probably

* 12 larvæ from each lot, *A1* and *A2*, were reared under precisely similar conditions :—
Of the "Heated," 7 attained maturity; mortality 41 per cent.
,, "Cooled," 11 ,, ,, ; ,, 8 ,,

because the less resistant eggs had not been weeded out of the latter batch by immersion prior to storing.

DATES OF HATCHING OF LOT *B* AND THE BALANCE OF THE RESISTANT EGGS OF LOTS *A*1 AND *A*2.

LOT.	MARCH.						APRIL.														
	25	26	27	28	29	30	2	5	6	7	8	9	10*	11	12†	13	14	15	16	18‡	19
*A*1 (cooled)...	...	10	...	...	1	2	1	...	...	1	...	...	7	3	41	12	3	1	...	6	3
*A*2 (heated)...	...	1	...	...	...	2	...	...	1	2	...	...	16	4	23	3	...	...	...	1	3
B (stored dry)	109	15	16	17	6	...	...	1	1	1	2	1	32	22	3	5	3	...	2	4	5

* On the 10th April the eggs hatched within 1 hour of the *commencement* of the cooling.
† The second cooling on the 12th April was slight, the fall being only 3° or 4° F., but it was long continued, lasting 5 hours.
‡ The third cooling on the 18th April was for 1 hour, the fall being from 85° F. to 74° F.

The final figures, although only approximate, are worth consideration. Of Batch *A*, 20 per cent. hatched on first immersion. Of the cooled resistant eggs (*A*1), 27 per cent. had hatched before they were dried and stored; 22 per cent. hatched subsequently, or, altogether, 49 per cent. Of the heated resistant eggs (*A*2), 22 per cent. hatched before and 22 per cent. after drying and storing; altogether 44 per cent.

The total number of Batch *A* which hatched is therefore 64 per cent., while of Batch *B* 41 per cent. hatched up to the time of the accident.

Of the totals, 36 per cent. of *A* had hatched in response to lowered temperature, and of *B*, 9 per cent.

The evidence afforded by these experiments seems fairly conclusive testimony that "cooling" is an important stimulus to hatching, and most probably is the effective factor when eggs are dried and re-immersed, or when fresh water is added to the pan containing the eggs.

It is to be noted that there is an underlying constitutional variability which withholds some of the eggs from hatching in spite of the stimulus. This appears to be of a zone-like character; that is to say, repetition of the stimulus at short intervals is less effective than if it is again applied after a greater lapse of time.

A further complexity arises from the fact that the zone-like character of this constitutional resistance to *stimuli*, together with the *resting habit as a whole*, may be suspended, with the exception of a small percentage of eggs, if certain conditions prevail at or about the period of incubation.

The experiment (No. XVIII.) performed to elucidate Question (7) was only planned and carried through at a late stage of the research when time did not permit of its repetition. The evidence it affords is, however, so definite and conclusive, with regard to the determining powers of drought or humidity (subsequent to incubation) either to bring the resting habit into action or to allow it to remain latent, that the only point remaining to be solved would seem to be whether the effect is invariable and relates to all eggs laid or if it is occasional only, relating possibly to a seasonal change in the constitution of the eggs. An answer on this last point would require a series of experiments carried out at, say, monthly intervals and continued over a period of 18 months to 2 years.

Experiment No. XVIII.

IMPORTANCE OF DRY OR HUMID CONDITIONS AS FACTORS IN INDUCING THE IMMEDIATE OR DEFERRED HATCHING OF EGGS.

A pan of water with two strips of filter paper, one end of which dipped into the water, while the other hung over the rim, was placed in a cage where females of *S. fasciata* were laying freely. Over 400 eggs were deposited on the filter paper during the night of the 10th April. The pan, with the eggs undisturbed, was then placed in a moist chamber (saturated atmosphere) for 50 hours to allow the eggs to incubate. A few of the eggs that were exactly on the water level or partly submerged, hatched.

The unhatched eggs were then divided into lots, one of which, Lot *A*, containing 192 eggs, was immediately immersed in a pan of water. 189 of the eggs hatched within 30 minutes. The 3 resistant ones, which were short, stumpy eggs, were kept immersed for 10 days; they were then dried and partly collapsed. They were again immersed for another 20 days and then dissected. Two contained dead larvæ and from the other a living larva was extracted.

The other portion of the batch, Lot *B*, containing 193 eggs, was allowed to dry on the bench. By the next day the number had been reduced to 168, owing to the attacks of *Psocidæ* (a species belonging to the genus *Clothilla*). Of this 168, 43 were more or less collapsed. (To a greater or less extent this collapsing may have been due to the *Psocidæ* perforating the eggs.)

Lot *B* was divided into:—

*B*1. Containing 86 eggs (15 of which were more or less collapsed). These were immersed after 24 hours' drying.

*B*2. Containing 82 eggs (28 of which were more or less collapsed). These were immersed after 7 days' drying.

The pans containing *B*1 and *B*2 were kept together and treated exactly alike as regards "cooling."

Results.

*B*1.—86 eggs, 15 of which were more or less shrunken, were immersed after 24 hours' drying on the 14th April.

Lot *B*1.	Date of hatching.														Total which hatched.	Percentage which hatched.
	April.		May.				June.									
	15	28	12	19	20	21	5	10	11	12	14	16	18	19		
Immersed 14th April ...	18	12	4	...	1	...	1	2	8	1	11	4	5	5	72	84

Remaining eggs dissected 21st June and found to be dead.

*B*2.—82 eggs, 28 of which were more or less shrunken, were immersed after 7 days' drying on the 20th April.

Lot *B*2.	Date of hatching.														Total which hatched.	Percentage which hatched.
	April.		May.				June.									
	21	28	12	19	20	21	5	10	11	12	14	16	18	10		
Immersed 20th April ...	35	...	...	1	...	2	...	...	6	...	...	...	...	...	44	54

The remaining eggs and eggshells of Lot *B*2 were counted and carefully examined on the 5th July:—

59 had uncapped,
3 had collapsed,
8 apparently sound eggs were dissected:—6 contained *living* larvæ, 1 a dead larva, 1 was infertile.

The remaining more or less shrunken eggs contained dead larvæ.

The only feasible way of accounting for the discrepancy between the larval record and the shells is to suppose that, although a number of the eggs uncapped, the larvæ failed to get free, a by no means unusual occurrence, but the number (15) in this instance, is rather high, in relation to the size of the batch.

Remarks and Notes.

On the 28th April and the 12th, 19th and 20th May, the pans containing the eggs were placed in an ice chest, the temperature of the water falling about 10° F.

On the 20th May, after the cooling, both lots were dried:—

Of *B*1, 31 eggs retained their full shape.
„ *B*2, 11 „ „ „

Both lots were again immersed and put out of doors for the night to cool the water.

On the 3rd June both lots were again dried:—

Of *B*1, 36 eggs retained their full shape.
„ *B*2, 13 „ „ „

Both lots were again immersed.

On the 5th June and following days the pans were placed out of doors each evening so that the water might be cooled at night.

Experiment No. XIX.

AGITATION OF THE WATER AS A FACTOR IN HATCHING.*

Mitchell (1907) states that Dupree found agitation to be a factor in the hatching of ova of species of mosquitoes other than *Anopheles*, which deposit their eggs singly.† It was noticed that disturbance of water in which eggs were placed was coincident with the appearance of newly hatched larvæ of *S. fasciata*, but the phenomenon, being only of occasional occurrence, was rejected as a cause of hatching, in favour of the view that the agitation merely made larvæ that had been recently hatched show themselves, trial stirrings giving no consistent results. Upon reading Mitchell's statement, the following experiments were carried out:—

A batch of eggs laid 4 or 5 weeks previously, which had been dry for 3 weeks, was placed in water—temperature about 73° F. 150 to 200 hatched within a few minutes, and by next morning 50 to 70 more larvæ were out. After an interval of 6 or 8 hours, during which none of the remaining eggs hatched, the water was agitated by shaking. 1 larvæ emerged and died. After a period of 20 hours, during which no more eggs hatched, the water was again agitated by a violent shaking. None of the eggs hatched. After 28 hours the water containing the eggs was placed out of doors to try the effect of cooling—none of the eggs hatched.

* Experiments now in progress show that the contamination of water in which the eggs are lying has a marked effect on their hatching. Two trials performed since the MSS. went to press will serve to illustrate this clearly.

Into each of two glass pans, containing 100 cc. of tap water at 65° to 70° F., was placed one half of a slip of paper with upwards of 400 eggs of *S. fasciata* on it, there were approximately 200 eggs in each pan. To one pan (*A*) was added 3 cc. of water from a beaker which had been allowed to incubate at 97° F. for 48 hours with a fragment of human faeces in it. This water was thick and brown with the characteristic smell. To the other pan (*B*) nothing was added.

After 4 hours 14 larvæ had emerged in pan *A*, none in *B*.
„ 20 „ 127 „ were swimming „ *A*, and 6 „ *B*.
„ 70 „ 136 „ „ „ „ *A*, „ 42 „ *B*.

The experiment was repeated, using fresh horse dung in place of human faeces.

No larvæ emerged in the first hour.

After 18 hours 148 larvæ had emerged from the eggs in pan *A* (contaminated water) and 11 in pan *B* (tap water only).

3 cc. of the manure water was then added to pan *B*. After 18 hours 159 larvæ had emerged, the stage of their growth suggesting that they had emerged within an hour or two of the addition of the manure water.

Further and more exact experiments with sterilized eggs and fluids are now being carried on by Dr. E. E. Atkin and myself. These, while supporting the above tests, suggest that the results are due to bacterial action. Under certain conditions eggs will not hatch while the fluid in which they are immersed remains sterile, but the infection of the fluid with bacteria causes the larvæ to emerge within a few hours.

† "Mosquito Life" (Page 26). Evelyn Groesbeeck Mitchell. G. P. Putnam & Sons, New York and London, 1907.

Time did not permit of the experiment being followed further. A second trial was made with a large batch of eggs laid 4 months previously. The batch was divided into two portions; both lots were immersed in beakers containing 200 cc. of water. Hundreds of larvæ emerged within a few hours. After 24 hours had elapsed, hatching had declined to a minimum and 6 hours later, no larvæ having emerged in either beaker, one of them was vigorously shaken while the other was placed out of doors for the night. Next morning 8 larvæ had emerged from the eggs in the cooled beaker; none had emerged in the one which had been shaken. The shaking and cooling were repeated 48 hours later, but none of the eggs hatched, and a later repetition was also ineffectual in both cases.

Time did not permit of the experiment being carried further. These trials cannot be considered as conclusive, but they suggest, if Experiments Nos. XIV. to XVI. are also taken into account, that agitation, if a stimulus to hatching, is less effectual in compelling larvæ within the eggs, which have not yet reached their hatching zone or period, to emerge, than cooling.

Experiment No. XX.

EXPERIMENTS RELATING TO THE PERIOD DURING WHICH THE EGGS OF *STEGOMYIA FASCIATA* RETAIN THEIR VITALITY WHEN OUT OF WATER.

The eggs laid on a filter paper or fallen leaves of the cottonwood tree were placed in wire gauze tubes or paper envelopes. In some cases, after the paper envelopes were placed in wire gauze tubes, these were again covered with paper in an attempt to exclude small predatory insects, such as ants, which could get through the mesh of the wire gauze. In spite of all precautions, however, the intended comparative statistical form of the experiments was vitiated owing to the ravages of one of the *Psocidæ* (book lice), a species belonging to the genus *Clothilla*. In many cases only a few out of hundreds of eggs stored remained to be tested, while in experiments where the destruction was less obvious it was impossible to form any estimate of the percentage of mortality due to long storage, apart from the attacks of these insidious little foes. As a consequence, the experiments only afford evidence of the period during which the eggs remain viable under various conditions, and not of the percentage which survive.

The tests were designed to fall into two Sections: (*A*) in which the eggs were exposed to the weather, and (*B*) where they were under cover. This plan had to be modified, however, to prevent the loss of eggs due to their being washed away by heavy rain, or to their hatching in small accumulations of water on the leaves or paper on which they rested.

During the dry season the tubes containing the eggs in Section *A* were not sheltered from sun or rain. An examination early in March showed that where paper coverings were used they had been eaten into holes by snails and millipedes, while both ants and *Psocidæ* had penetrated into the envelopes containing the eggs. In cases where no envelopes or paper coverings to the tubes had been used, many of the eggs had either fallen off or had been washed off by late rains, and in a number of cases eggs had hatched. With the oncoming of the rains further instances of eggs hatching on wetted paper

occurred, and it was found necessary to cover the eggs with inverted tins to guard against further flooding.

In a few instances only was it possible to follow up separately the larvæ which hatched from different batches. Where time did not permit of this they were turned into a common breeding pan, from which large numbers of normal adults were reared. The tests dealing with the viability of the eggs were carried out in the same places as those dealing with the length of adult life. Charts giving curves of temperature and humidity for these situations will be found, with short descriptive notes, in the Experimental Series No. XXXV., on pages 64 and 92 to 101.

Section *A.*

Pen in Hospital Compound.

Eggs laid on leaves and filter paper, not placed in envelopes and tube not covered with paper—only a few eggs remained to be tested :—

Batch 1.—Laid during December ; immersed 18th June. 1 hatched within 24 hours, two or three others emerged within the next two or three days ; one of these died in its first skin shortly after emergence.

Vitality retained for 170 *to* 180 *days.*

Batch 2.—Laid during December, immersed 18th June. 1 hatched on the 18th, 1 on the 19th, 1 on the 20th and 1 on the 21st.

Vitality retained for 170 *to* 180 *days.*

One of the larvæ pupated on the 6th day after immersion ; a male and a female emerged on the 8th day. Other specimens emerged later ; the last to emerge was a male which took 11 days.

Eggs laid during January, on filter paper and placed in an envelope were also immersed on the 18th June, but failed to hatch.

Under Pen in yard at 26, Westmoreland Street.

Laid on leaves and filter paper, not placed in an envelope and the tube not covered with paper until commencement of the rains :—

Batch 1.—Laid during December, immersed 20th June. 2 hatched on the day after immersion ; 1 larva died within an hour or two ; three or four were hatched within the next few days.

Vitality retained for 175 *to* 180 *days.*

Batch 2.—Laid during December ; immersed 23rd June. None hatched on the day of immersion, but several on the succeeding days.

Vitality retained for 175 *to* 180 *days.*

Two males and one female emerged within 7 days of the immersion of the eggs and two females on the 8th day.

Batch 3.—Eggs laid during January, on filter paper placed in an envelope which was kept in a paper-covered tube. Only 36 out of several hundred eggs remained. Immersed 23rd June ; 7 hatched next day, 7 on the second and 2 on the third day.

Vitality retained for 145 *to* 150 *days.*

Development of larvæ not recorded.

On Ground in Mosquito House.

Laid during December on leaves and filter paper, not placed in an envelope and the tube not covered with paper until the commencement of the rains.

Immersed 13th July; one hatched the following day; no more emerged during the week that the trial was continued.

Vitality retained for 195 *to* 200 *days.*

Eggs laid on filter paper and placed in an envelope which was kept in a paper covered tube:—

Immersed 13th July.

1 hatched within 24 hours.
2 ,, ,, 48 ,,
4 ,, ,, 72 ,,
1 ,, ,, 120 ,,

Vitality retained for 165 *to* 170 *days.*

Eggs laid during December on filter paper and placed in envelopes, but not placed in tubes or again covered with paper:—

(1) A batch of eggs laid during December on filter paper was placed in water for 24 hours and the eggs which *did not* hatch were dried and stored.

Immersed 20th July.

1 hatched within 2 hours.
7 ,, ,, 48 ,,
2 ,, ,, 72 ,,
2 ,, ,, 120 ,,

Vitality retained for 200 *days.*

(2) Laid during December on filter paper and stored in an envelope without previous immersion.

Immersed 20th July.

53 hatched within 2 hours, 7 larvæ died within a few hours of hatching.
165 ,, ,, 24 ,, , 12 larvæ died within a few hours of hatching.
52 ,, ,, 48 ,, , 4 larvæ died within a few hours of hatching.
24 ,, ,, 72 ,,
3 ,, ,, 96 ,,
2 ,, ,, 120 ,,

Vitality retained for 200 *days.*

(3) Laid during December on filter paper and stored in an envelope without previous immersion.

Immersed 20th July.

20 hatched within 2 hours.
6 ,, ,, 24 ,,

Vitality retained for 200 *days.*

Section *B*.

Eggs Stored in Pit in the Mosquito House.

Laid during December on leaves and filter paper, not placed in envelope, tube uncovered :—

Immersed 6th July.

(1) 1 hatched within an hour.

Vitality retained for 187 *days.*

(2) Laid 7th to 14th December.

Immersed 6th July.

1 hatched within an hour.
4 ,, ,, 24 hours.
3 ,, ,, 48 ,,
1 ,, ,, 72 ,,

Vitality retained for 204 *days.*

Laid on filter paper during January, placed in an envelope which was kept in a paper covered tube.

Immersed 6th July, but failed to hatch.

Eggs laid on filter paper and kept in paper envelopes in the animal house until 31st December, then stored in the mosquito house pit :—

(1) Laid 20/23 October. Immersed 21st May.

About one dozen eggs of full and sound appearance remained.

2 hatched within 2 hours.
1 ,, after 17 days' immersion.
5 ,, ,, 20 ,, ,,

Vitality retained 210 *days.*

(2) Laid 24/26 October. Immersed 6th July.

Only 6 eggs of full and sound appearance remained out of about 100 stored ; there were many collapsed eggs, and signs of attack by *Psocidæ* were evident. None of the eggs hatched during a period of 10 days' immersion. On dissection, 1 living larva and 2 dead ones were extracted, the other 3 eggs collapsed while in the water.

Vitality retained 260 *days.*

(3) Laid during November. Immersed 25th July.

1 hatched within 48 hours.
1 ,, ,, 6 days.

Vitality retained 240 *days.*

Eggs laid on filter paper and kept in paper envelopes in the animal house until 31st December, then placed on ground in mosquito house under an inverted tin :—

Laid 29th October—5th November. Immersed 14th July.

1 hatched within 24 hours.

Vitality retained 250 *days.*

No more hatched during 10 days' immersion. On dissection a number of eggs were found to contain dead larvæ.

A tin containing leaves and filter paper on which eggs had been laid during January was left open on the Laboratory bench from January until the end of June ; it was then filled with water—11 adults were reared.

Vitality retained for 140 *days.*

An attempt was made to test the effect of exposure to the sun on eggs laid in tins and on leaves lying in tins. They were placed on the ground under a wire gauze pen in a part of the hospital compound which received full sunlight from 10 a.m. to 4 p.m. The eggs were laid in December and the exposure commenced on the 31st of that month, but the experiment came to an untimely end in January owing to the curiosity of the son (aged 5) of a German prisoner (his mother was a patient in the Hospital).

A second attempt was made after his departure in February. Three tins and a glass jar in which eggs had been laid during January, either on the sides or on dead leaves contained in them, were exposed. Water was poured into these receptacles on the 5th June.

Eggs hatched in one of the tins only, and several *Stegomyia fasciata* were reared by the middle of June.

Viability of Eggs of *Stegomyia fasciata* laid in Sierra Leone and brought to England.

Eggs from all these batches had been tested from time to time in Freetown and viability had been proved for from 4 to 6 months.

Laid 20th to 23rd Oct., 1914. Immersed 1st Sept., 1915. Failed to hatch.
„ 24th to 26th „ „ „ „ „ „
„ 26th to 29th „ „ „ „ „ „
„ 5th to 13th Nov. „ „ „ „ „ „

Laid 15th January, 1915. Immersed 16th Sept., 1915. Two hatched within 24 hours.

This was a large batch laid on filter paper, which had become so firmly attached to the tin sides of the breeding pan that on drying it could not be detached without scraping. The tin was cut up and portions with the undisturbed eggs on them were immersed. The two eggs that hatched only represent a small percentage of the eggs tested; certainly not more than 2 per cent.

Laid June-July, 1915. Immersed 16th September, 1915. Hatched freely.

Laid during July, 1915, on wood. Immersed 20th October, 1915. Hatched freely within 2 hours of immersion.

Laid during January on filter paper that became firmly attached to the side of a tin. Immersed 20th October, 1915. Hatched freely within 2 hours of immersion. *Vitality retained for 262 days.*

Experiment No. XXI.

TEMPERATURES WHICH EGGS OF *STEGOMYIA FASCIATA* ARE ABLE TO WITHSTAND.

It was found at Freetown that eggs easily survived a day or two at blood heat, 97° F., but more extreme tests were not practicable.

The following tests were carried out at the Lister Institute:—

First Test.

Eggs laid June–July, 1915, at Freetown on slips of filter paper and brought to England in a wooden box,

A slip was divided and one portion was kept in an incubator at 105·8° F. for 48 hours; the other portion was kept at room temperature, 65° to 70° F. On immersion the eggs on the slip placed in the incubator failed to hatch, while those on the control slip hatched freely.

Second Test.

A slip was divided into four, and the eggs on the several portions were submitted to the following conditions for 24 hours, the eggs submitted to heat were placed in a moist cell. At the expiration of the 24 hours all were immersed in water at about 64° F.

	After immersion at 64° F.		
	2 hours.	24 hours.	72 hours.
Incubator at 107·6° F.	...	...	...
Hot room at 96·8° F.	1 hatched	40 per cent. hatched.	70 per cent. hatched.
Incubator at 78° F. ...	A number	70 ,, ,,	75 ,, ,,
Cold room at 28° F. ...	1 hatched	20 ,, ,,	25 ,, ,,

Third Test.

A large batch of eggs laid during June and July in Freetown were placed in the cold room of the Lister Institute on the 18th September, and submitted to a temperature of 28° to 30° F. for 25 days; they were then placed in water at 65° F., subsequently raised to 75° F.; none hatched, but eggs of a control batch, kept at 65°–70° F, did so.

Fourth Test.

A batch of eggs laid on filter paper in London by specimens reared from Freetown eggs was divided into four lots; these were kept for 24 hours at 29°–30° F., 75° F., 95° F., and 102° F. respectively They were then placed in water at 65° F. and gradually raised to 75° F. after 20 hours' immersion.

Of the lot submitted to—

29°–30° F., 50 out of 69 hatched = 72 per cent. (one larva died).
75° F., 6 ,, 50 ,, = 12 ,,
95° F., 10 ,, 53 ,, = 19 ,,
102° F., none ,, 50 ,,

The pans of water containing the eggs were then allowed to cool down to 65° F. and examined after 4 hours. Of the lot submitted to—

29°–30° F., 6 had hatched = 9 per cent.
75° F., 20 ,, ,, = 40 ,,
95° F., none ,, ,,
102° F., 1 ,, ,, = 2 ,,

The pans were again kept at 75° F. and examined after 76 hours. Of the lot submitted to—

29°–30° F., none had hatched.
75° F., 2 ,, ,, = 4 per cent.
95° F., 1 ,, ,, = 2 ,,
102° F., 3 ,, ,, = 6 ,, (and were dead).

The pans were again allowed to cool to 65° F. and left. Of the lot submitted to—

29°–30° F., none had hatched.
75° F., 3 ,, ,, = 6 per cent.
95° F., 1 ,, ,, = 2 ,,
102° F., none ,, ,,

The pans were again placed at 75° F. and examined 20 hours later. Of the lot submitted to—

29°–30° F., none had hatched.
75° F., 8 ,, ,, = 16 per cent.
95° F., none ,, ,,
102° F., 1 ,, ,, = 2 ,,

The pans were again allowed to cool to 67° F. and left for 4 hours Of the lot submitted to—

29°–30° F., none had hatched.
75° F., 1 ,, ,, = 2 per cent.
95° F., 3 ,, ,, = 6 ,,
102° F., 1 ,, ,, = 2 ,,

No further hatching occurred within a period of 4 days.

RESULT.

Temperature to which eggs were submitted for 24 hours.	Number of eggs tested.	Hatched within 128 hours.
29°–30° F.	69	56 = 81 per cent.
75° F.	50	40 = 80 ,,
95° F.	53	15 = 28 ,,
102° F.	50	6 = 12 ,,

Fifth Test.

Effect of heat *before* incubation.

A batch of eggs that had been laid not more than fifteen or sixteen hours was submitted to 97° F. for thirty minutes. The batch was then divided, half the eggs were subjected to a further rise of temperature to 114·8° F. for thirty minutes. Both lots were then stored dry for a few days at about 65° F. and then placed in water. All the eggs heated to 114·8° F. completely collapsed, and no larvæ emerged, while most of the control eggs hatched.

Experiment No. XXII.

ENEMIES IN THE EGG STAGE.

Under natural conditions there are probably many more enemies of this stage than appear when the eggs are stored under artificial conditions and protected against the attacks of vertebrates and the larger insects.

It is likely that some species of small bird may search out and devour the eggs in a similar manner to the Tits which destroy such multitudes of eggs of the winter moths in Northern Europe. Predaceous beetles and beetle larvæ possibly take toll, but no actual evidence of any of these attacks was forthcoming.

In captivity eggs stored out of doors were lost owing to the disturbing action of millipedes and woodlice, which gnawed the paper on which the eggs were laid, and to which they were somewhat loosely attached, but here again neither observation nor circumstantial evidence suggested differential action of such large enemies, which should have been apparent if the eggs were used as food. The same kind of loss to stored eggs occurs when they are laid on leaves, though this is probably chiefly due to bacterial action rotting the surface of the leaf in damp weather.

Ants might be expected to seek out and carry off the eggs, but all the evidence both general and experimental is entirely negative. It seems almost certain that the eggs must in some way be rendered distasteful to them, otherwise it is impossible to understand how the species of mosquitoes which rely on drought resisting eggs to tide over the dry season, could possibly survive in the face of the omnipresent activity of these insects in their search for food.

Indifference alone is hardly a sufficient reason for the passing over of eggs by a species of ants, one of which was detected in the act of laboriously carrying away a shred of aluminium foil.

The disappearance of eggs from boxes with such close-fitting lids that no ant could enter contrasted with the fact that they might be left uncovered on the Laboratory bench for days without interference, although ants were continually searching for and carrying away dead insects or any dried scraps of insects that might be about. This led to the following experiments, which prove conclusively that a species of *Psocidæ* (book lice), apparently the same species which occurs in Europe, was the enemy which had wrought such extensive destruction among the experimental eggs. It was found in nearly every situation, both indoors and out, which afforded sufficient cover. The *Psocidæ* themselves are attacked and utilized as food by a species of *chelifer*, or false scorpion.

Into a glass-topped entomological box, which contained remnants of dead mosquitoes and a numerous brood of *Psocidæ*, were placed two slips of paper on which eggs had been laid. On No. 1 the eggs had been laid and allowed to dry a month previously; at the commencement of the test there were 20 full eggs and 2 collapsed ones on it. On No. 2 the eggs had been laid and dried 5 months previously; examination showed that there were 14 full, 10 shrunken and 3 collapsed eggs on it.

On the following day, No. 1 had 13 full and 2 collapsed eggs on it, while No. 2 had 4 full, 8 shrunken and 2 collapsed eggs. There were also

fragments of partly eaten eggs, and a careful examination showed that 2 of the apparently undisturbed eggs had small holes gnawed in them.

By the third day, in No. 1 there remained 4 full and 2 collapsed eggs, and in No. 2 but 1 full egg and some partially eaten remnants.

On the fifth day nothing but fragments of shell remained, which were shortly devoured, a special feature of the work of the *Psocidæ* being the completeness with which they clear up if time permits, not even the tiniest fragment of shell being left to afford evidence of the nature of the attacking agent.

The next test was to place a small batch of freshly laid eggs in the box. On drying there were found to be 22 full and 2 collapsed eggs. Two days later not a vestige of the eggs remained.

The third test was a comparative one. A large batch of freshly laid eggs was dried and the collapsed eggs removed, it was then divided into two portions.

Lot 1, consisting of 82 eggs, was placed in the box.

Lot 2, consisting of 67 eggs, was placed on the Laboratory bench, and left uncovered except on two occasions. On the 3rd of June a chip box was accidentally placed over the paper slip on which the eggs had been laid. On the 4th June the paper was turned over so that the eggs were between the paper and the bench. In both instances the accidental covering led to attack on the eggs.

Lot 1.

82 Eggs placed in Box containing numbers of Psocidæ.
Record of Reduction in Numbers.

May.			June.											
26	28	31	3	4	5	6	7	8	9	10	11	12	13	15
82	77	76	68	61	54	47	43	28	17	8	5	3	1	0

Lot 2.

67 Eggs left exposed on Laboratory Bench.
Record of Reduction in Numbers.

May.			June.											
26	28	31	*3	*4	5	6	7	8	9	10	11	12	13	15
67	67	67	45	42	42	42	42	42	42	42	42	42	42	42

* On the 3rd and 4th June the eggs were covered.

On the 15th June Lot 2 was transferred to the box.
After 24 hours only 20 eggs remained.
After 72 hours only 1 full, 1 shrunken and 1 collapsed egg remained.

(B) LARVÆ AND PUPÆ.

Experiments Concerning the Description and Quantity of Food needed by Larvæ of *Stegomyia fasciata*

General Notes.

The high mortality which occurs when the captured larvæ are simply placed in jars of water to rear, combined with the experience gained in breeding mosquitoes from the egg, show that an ample store of organic matter in the water to start with, or the addition of fresh food at intervals is essential. The description of organic matter used may vary within wide limits. Dead leaves, boiled white of egg, rice or other grain, dead insects, fæces, etc., all give good results provided the quantity is adjusted to the number of larvæ and quantity of water. Oily or fatty foods (such as cockroaches) may, however, easily cause a high or even a total mortality. So long as the water is free from oil or fat it may be very foul, cloudy or thick, and swarming with bacteria to an extent which suggests a broth culture. In the case of rice the water was so thick in some of the experiments as to resemble thin starch. Dead insects and other small animals, together with leaves, probably afford the chief natural sources of nourishment for the larvæ of *Stegomyia fasciata* and most of its relatives as well; but apart from these, the fall of organic dust on any uncovered area would most likely suffice for a limited number of larvæ to attain the adult stage.

With *Stegomyia* and, so far as a limited experience goes, other *Culicine* mosquitoes, competition for the available food supply is very keen. To obtain a start before other organisms have had time to develop is an evident necessity if large broods are to be reared. Any quantity of fresh food added to standing water will not reproduce the favourable conditions which obtained at the initiatory filling of the breeding pool. This may be observed under

natural as well as artificial conditions, and is probably largely due to the killing of the newly hatched larvæ by the larger ones, as pointed out by MacGregor (1915).

Stegomyia with its resting eggs, some of which are ready to hatch within a few minutes, and others within two or three hours of immersion, is better adapted to take full advantage of the late and early rains than species which have to deposit eggs requiring some 30 hours' incubation, after the pool has formed. Apart from such obvious competitors for food as tadpoles, ephemerid larvæ and those of species of *Chironomus* or other omnivorous water insects, a species of *Ostracoda* belonging to the genus *Cypris* is a highly successful competitor if it gets a start in breeding pans. Once it is established, few, if any, of the mosquito larvæ get sufficient food to finish their development.

Pans or jars, the sides of which become green with the growth of *Algæ*, are also very generally impossible for further breeding, but whether or no this is due to the *Algæ* or some secondary cause is undetermined.

The first moult is not passed by larvæ put into clean but unfiltered tap water. In the absence of added organic matter the larvæ seem unable to pass to the second skin until the death of some of their fellows provides the survivors with nutriment. If after a short but sharp period of starvation abundant food is given, the mortality may be low, and the larvæ reach maturity quickly, but produce small adults. On the other hand, if the period of scarcity is continued, the mortality is high, and the larval life may be unduly prolonged, possibly up to seventy days.

Under the most favourable conditions the larval life may be passed within four days, and males have completed their development within five days five hours.

The fact that larvæ breeding in water containing little organic matter produce small adults* has its practical side when cleanly tanks and covered cement-lined cisterns replace wooden butts or other dirty storage receptacles. The covers need to be of a smaller mesh, not less than 18 × 18 to inch, because in addition to the possibility of these dwarf females getting through the netting

* See also under "Enemies," page 79.

when seeking water to lay their eggs, there is always the risk of eggs that have been deposited in gutters being washed in through the netting and producing small sized specimens, which will squeeze through netting they would not otherwise pass in an endeavour to get out.

Protracted development or lagging may occur even in the presence of an abundant food supply; a few larvæ of any given batch will frequently lag behind their fellows. These lagging larvæ are often unhealthy and die, but they sometimes complete their development and produce normal adults after three or four times the usual period.

When considering the experiments some allowance must be made in respect of sex, the early males being usually a day quicker in their development than the females.

All the experiments with larvæ were performed in the Laboratory of the Colonial Hospital, and a Chart (No. 1) embodying the records of temperature and humidity from December, 1914, to July, 1915, is appended. A partial record of the maximum and minimum temperature and extremes in each week from September 11th to December 4th is set forth in Chart No. 9 on page 101.

Experiment No. XXIII.

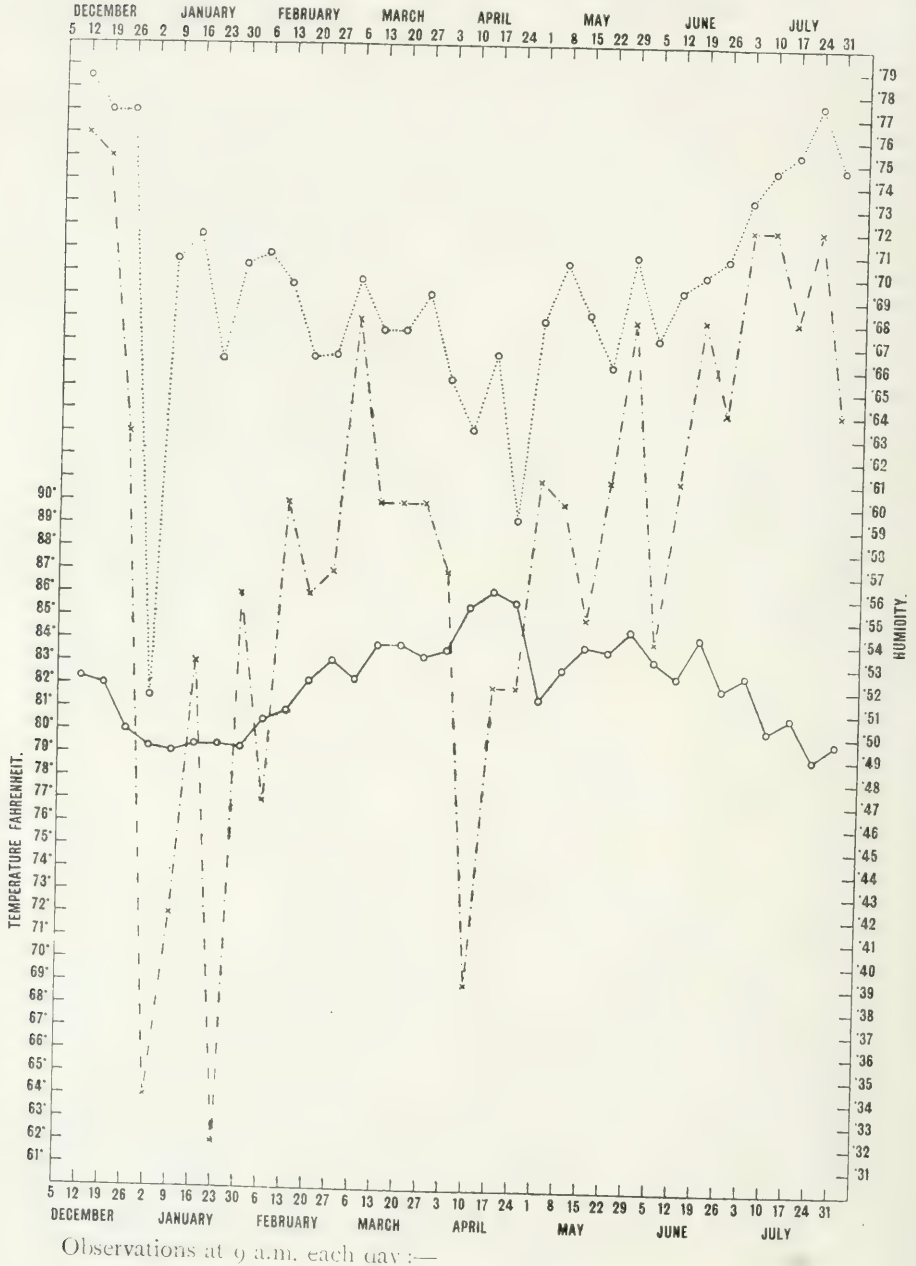
QUANTITY AND NATURE OF FOOD REQUIRED.

200 cc. of tap water was put into each of three beakers.
To N.R. ·2 gr. of uncooked native rice was added.
To P.R. ·2 gr. of uncooked polished rice was added.
To W.E. ·2 gr. of hard boiled white of egg was added.
12 larvæ just out of their eggs (from a batch of eggs which had been dried and then re-immersed) were put into each beaker, and these were covered with thin cotton to exclude dust and small insects.
The temperature in the Laboratory during the course of the experiment averaged about 82 F.

2nd day after start—All the larvæ were of about equal size.
3rd „ „ „ N.R. and P.R. ahead of W.E.
4th „ „ „ P.R. most advanced; N.R. next, with W.E. a bad third, but all seemed equally healthy.
6th „ „ „ P.R., 5 already in pupal stage; N.R., larvæ full-grown, but no pupæ; W.E., almost all the larvæ a moult behind.

Chart No. 1.

Curves of Temperature and Humidity in Laboratory at Colonial Hospital, Freetown.



Observations at 9 a.m. each day :—

Temperature ———— Humidity, ...

Minimum Humidity record in each week — . — . — . — .

FINAL RESULT.

Lot.	Number of adults reared.	Time occupied from hatching to adult state.			Mortality.	Remarks.
		Shortest.	Average.	Longest.		
N.R.	9 males, 2 females	9 days	10 days	12 days (1 female)	8 per cent.	...
P.R.	6 males, 6 females	8 days	9 days	11 days (2 females)	Nil.	...
W.E.	1 male, 6 females	26 days	31 days	42 days (1 female)	42 per cent.	...

The quantities of food used are not, of course, equivalent, as the water content of the white of egg will be much greater than that contained in the rice.

Experiment No. XVII.

QUANTITY AND NATURE OF FOOD REQUIRED.

200 cc. of tap water was put into each of two beakers.

To P.R. 0·5 gr. of desiccated polished rice was added.

To W.E. 0·5 gr. of desiccated boiled white of egg was added.

16 larvæ, which had just emerged from eggs of the same batch as those used in the last experiment, were put into each beaker, and these were covered with thin cotton to exclude dust, etc.

The Laboratory temperature during the course of the experiment averaged about 82° F.

The larvæ in P.R. gained rapidly on those in W.E. at first, but subsequently the W.E. batch recovered most of the lost ground.

FINAL RESULT.

Lot.	Number of adults reared.	Time occupied from hatching to adult state.			Mortality.	Remarks.
		Shortest.	Average.	Longest.		
P.R.	10 males, 6 females	8 days	8 days	9 days (5 females)	Nil.	...
W.E.	10 males, 5 females	8 days	9 days	11 days (2 males)	6 per cent.	1 pupa died on the 13th day.

In this and the following experiments the food material was dried or desiccated before use.

Experiment No. XXV.

QUANTITY AND NATURE OF FOOD REQUIRED.

200 cc. of tap water was put into each of four beakers.

To O. nothing was added.

To P.R.O., 0·5 gr. desiccated polished rice was added.

To W.E.O., 0·5 gr. desiccated boiled white of egg was added.

To C.W.L., 1·0 gr. dried fragments of fallen cottonwood leaves was added.

20 larvæ just emerged from a large batch of eggs of mixed parentage, which hatched in response to cooling, were put into each. The beakers were covered with thin cotton to exclude dust, etc.

The temperature in the Laboratory at 9 a.m. during the course of the experiment averaged 79·4° F.

1st day :—No noticeable difference.

2nd day :—O., very little growth, no moults.
P.R., in second skin.
W.E., a few in third skin, but most in second skin.
C.W.L., far in advance of the others. Mostly well-grown in third skin, and a few approaching the third moult, but 2 larvæ still in first skin.

3rd day :—O., about half have grown, the remainder show no growth.
P.R., mostly full-grown in third skin, but a few only just past the moult.
W.E., mostly full-grown in third skin, but a few only just past the moult.
C.W.L., still ahead, but the gap between this batch and P.R. and W.E is lessening. None have yet reached the fourth skin, but a few are preparing to moult ; 2 still lag, they are now in second skin.

4th day :—O., all are now making progress in the first skin.
P.R., all are well-grown in fourth skin, except 2, one of which is in the second skin and the other in the third skin.
W.E., all but 3 are well-grown in fourth skin ; of the laggards, 2 are in the third and 1 in the second skin.
C.W.L., are mostly marking time, but the backward larvæ are progressing ; one is in the second and the other in the third skin.

5th day :—O., still in first skin ; little appreciable further progress.
P.R., 3 have pupated ; 2 larvæ are still in third skin ; the remainder are full-grown.
W.E., 1 living and 1 dead pupa ; 2 larvæ in third skin ; the remainder full-grown.
C.W.L., 6 pupæ, 1 larva in third and 1 in second skin ; the remainder full-grown.

6th day :—O., still marking time in first skin.
P.R., 16 pupæ, 1 full-grown larva and 1 in third skin.
W.E., 6 pupæ, several larvæ dead ; the remainder full-grown.
C.W.L., 13 pupæ, 1 larva in third and 1 second skin ; the remainder full-grown.

7th day :—O., still no progress.
P.R., 18 pupæ and 2 larvæ, 1 in third skin.
W.E., 9 pupæ, two or three more larvæ dead.
C.W.L., 5 adults, 9 pupæ and 4 larvæ, 1 still in second skin.

8th day :—O., only 16 larvæ living; two or three of these have moulted and are now in second skin.
P.R., 13 adults, 2 pupæ and 2 larvæ, 1 still in third skin.
W.E., 4 adults, 6 pupæ and 1 larva.
C.W.L., 5 adults, 4 pupæ and 4 larvæ, 1 still in second skin.

12th day :—O., 12 living larvæ, the largest backward in the second skin; the smaller ones still in the first skin.
P.R., finished.
W.E., 1 still in larval stage.
C.W.L., 3 still in larval stage; 1 only in third skin.

17th day :—O., 11 living larvæ, slight growth, but no moults since 12th day.
W.E., the last larva has now pupated.
C.W.L., 1 larva has pupated and an adult reared; the 2 remaining larvæ are both in fourth skin.

Final Result.

The larvæ of O. gradually died off, leaving a single survivor, which pupated after spending 48 days in the larval stage. A female specimen was reared. The larvæ did not kill one another, but lived on the decaying bodies of their fellows as they died.

Lot.	Number of adults reared.	Time occupied from hatching to adult stage.			Mortality.	Remarks.
		Shortest.	Average.	Longest.		
O. ...	1	50 days	...	...	95 per cent.	...
P.R...	16	8 ,,	8 days	9 days	20 ,,	1 larva died on 16th day.
W.E.	10	8 ,,	9 ,,	13 ,,	50 ,,	1 pupa died on 18th day.
C.W.L.	16	7 ,,	9 ,,	15 ,,	20 ,,	1 pupa died on 21st day.

When considering these results it is necessary to bear in mind three points :—

(1) the *quantity* of *organic matter* in relation to (2) the *quantity* of *water*, and (3) the number of larvæ in relation to both.

The result of O. affords further evidence of the result of insufficiency of food, but in a more acute form than W.E. in Experiment No. XXIII.

The mortality in P.R., as compared with the absence of deaths when the larvæ were fed on polished rice in the two earlier experiments, is probably not

due to any scarcity of food owing to the larger number of larvæ present, but either to overcrowding or pure chance.

With W.E. in this experiment, the increased mortality, as compared with the use of the same food in Experiment No. XXIV., is also explicable as the result of overcrowding or chance.

With C.W.L., however, the result should be studied in relation to the use of fallen leaves of the cottonwood tree in the later experiments, the suggestion clearly being that the quantity of food used was barely sufficient for the number of larvæ, though the mortality may have been influenced, as in P.R. and W.E., by overcrowding.

Experiment No. XXVI.

ASSIMILABILITY IN ADDITION TO QUANTITY AND NATURE OF FOOD.

This experiment was planned with a view to ascertaining if speed of growth depended upon the assimilability of food apart from its nature. It was hoped also that some evidence of the action of bacteria or other micro-organisms in relation to this process might be obtained.

Into six beakers were placed the following food materials, all of which had been dried for a week in the desiccator:—

P.R. 1, 0·5 gr. polished rice.
P.R. 2, 0.5 gr. ,, ,,
C.W.L. 1, 0·5 gr. fragments of fallen leaves of the cottonwood tree.
C.W.L. 2, 0·5 gr. ,, ,, ,, ,, ,,
E.L. 1, 0·5 gr. fragments of fallen leaves of a species of eucalyptus.
E.L. 2, 0·5 gr. ,, ,, ,, ,, ,,

To beakers P.R. 1, C.W.L. 1, and E.L. 1, 200 cc. of tap water was immediately added.

All six beakers were covered with thin cotton to exclude dust.

The temperature in the Laboratory at 9 a.m. during the course of the experiment averaged 81·5° F.

After 24 hours a microscopic examination of the water was made by wet film.

P.R. 1, showed a few slowly moving rounded cells (? yeast).
C.W.L., a few bacteria and infusoria in each field.
E.L., no sign of any organism.

After 46 hours a further examination was made.

P.R. 1, showed numbers of bacteria + + + + and some of the slowly moving rounded cells.
C.W.L. 1, showed bacteria, numerous + + + +, also some infusoria.
E.L. 1, ,, ,, ,, + + + ,, ,,

200 cc. of tap water was now added to beakers P.R. 2, C.W.L. 2, and E.L. 2.

A large batch of eggs of mixed parentage was immersed, and from the larvæ which emerged within 90 minutes, 30 were placed into each of the six beakers.

The following history is general, the "lagging" larvæ are not individually noticed.

1st day :—P.R. 1, ahead of P.R. 2, but not to the extent of a moult.
C.W.L. 1, ahead of C.W.L. 2, but to a less marked extent than with P.R.
E.L. 1, very slightly ahead of E.L. 2.

2nd day :—P.R. 1, well-grown in second skin ; P.R. 2, a full moult behind.
C.W.L. 1, rather less grown in second skin than P.R. 1.
C.W.L. 2, a moult behind C.W.L. 1 ; there is, however, less disparity between C.W.L. 1 and 2 than between P.R. 1 and 2.
E.L. 1 and 2 differ but very little from each other ; they are both behind the others. None are past the first skin.

3rd day :—P.R. 1, mostly in fourth skin ; a few almost full grown.
P.R. 2, more varied in growth ; only a few in fourth skin.
C.W.L. 1, the advanced larvæ are about parallel with P.R. 2, but the proportion still backward in third skin is larger.
C.W.L. 2, quite noticeably behind C.W.L. 1, but only as a question of growth, not of moults.
E.L. 1, are slightly in advance of E.L. 2 ; both are behind C.W.L. 2.

4th day :—P.R. 1, all full grown, except a few laggards, which make very slow progress.
P.R. 2, in fourth skin, but not quite full grown ; the laggards of this lot are, however, ahead of those of P.R. 1.
C.W.L. 1, not quite so advanced as P.R. 2.
C.W.L. 2, slightly behind C.W.L. 1.
E.L. 1 and 2, no noticeable difference ; both lots behind C.W.L. 2.

6th day :—P.R. 1, 15 or 16 pupæ ; one of the lagging larvæ is dead ; all the remaining larvæ full grown in fourth skin.
P.R. 2, 8 or 10 pupæ ; the lagging larvæ are now growing rapidly ; all the others are full grown in the fourth skin.
C.W.L. 1, no pupæ ; the larvæ are marking time as though food were failing.
C.W.L. 2, have quite caught up to C.W.L. 1, in fact, they look on the whole better fed, but there are no pupæ.
E.L. 1 and 2, are slightly behind the C.W.L's. in growth ; they differ between themselves in that E.L. 2 shows a smaller range of variation in growth.

From this time onwards it became evident that the larvæ which were given leaves as a source of nutriment (C.W.L. 1 and 2, E.L. 1 and 2), had reached the limit of their food supply. Their record continues as a long-drawn-out period spent in marking time, with short spurts of growth as larvæ died, and supplied the survivors with fresh sources of nutriment.

FINAL RESULT.

Lot.	Number of adults reared.	Time occupied from hatching to adult stage. Shortest.	Average.	Longest.	Mortality.	Remarks.
P.R. 1 ...	23	7 days	8 days	10 days	23 per cent.	...
P.R. 2 ...	29	8 ,,	9 ,,	11 ,,	3 ,,	...
C.W.L. 1	3	45 ,,	47 ,,	50 ,,	90 ,,	One larva lived until the 78th day, but failed to pupate.
C.W.L. 2	3	11 ,,	12 ,,	12 ,,	90 ,,	Three larvæ lived until the 47th day, but failed to pupate.
E.L. 1 ...	2	49 ,,	49 ,,	49 ,,	93 ,,	One larva lived until the 66th day, but failed to pupate.
E.L. 2 ...	1	18 ,,	...	...	...	On the 46th day this item of the experiment was terminated by an accident. There were 10 or 11 larvæ living at the time.

It is doubtful if the difference in mortality between the pair P.R. 1 and 2 is of any significance, but the high death rate among the larvæ given leaves is almost certainly the result of insufficiency of food.

The advantage in speed of growth between the pairs during the early days of the experiment, so far as the P.R. and C.W.L. are concerned, was clearly with the larvæ in the beakers where there had been two days for the food to soak and diffuse, or for micro-organisms to develop. With E.L. the difference was slight, which in view of the sparse growth of bacteria in the water in beaker E.L. 1 after 46 hours, is significant of some relation between the growth of bacteria and the assimilability of the food.

That the final advantage tended to be with the lots in which bacterial growth was not given any start in advance of the larvæ appears to suggest that, if bacteria and other micro-organisms are a direct source of food, they abstract a certain amount of nutriment, which is not subsequently recovered when the larvæ ingest them.

Experiment No. XXVII.

PRESENCE OF BACTERIA CONSIDERED ALSO.

This experiment was planned on similar lines to No. XXVI., but was varied as regards the description of food and number of larvæ used, in the hope of getting more nearly into touch with the problem of the

relationship between larval growth and the development of bacteria in the water. An addendum, of which a short account is appended, was undertaken to allow of larvæ and pupæ being dissected to make gut smears, without interference with the breeding averages and mortality percentages in the main experiment.

Into six beakers were placed the following :—

P.R. 1 and 2, each 0·5 gr. polished rice.

C.W.L. 1 and 2, each 0·5 gr. fragments of leaves of cottonwood tree.

C. 1 and 2, each 0·5 gr. fragments of dead cockroach.

All these food materials had been thoroughly dried in a desiccator and coarsely powdered before weighing.

200 cc. of tap water was at once added to P.R. 1, C.W.L. 1, and C. 1.

All six beakers were covered with thin cotton to exclude dust, etc.

The temperature in the Laboratory at 9 a.m. during the course of the experiment averaged 82·2° F.

After three days a microscopic examination of the water for germs was made :—

P.R. 1, showed bacteria + + and a few slowly moving rounded cells (probably yeasts).

C.W.L. 1, showed bacteria + + +.

C. 1, showed bacteria + + + + +.

200 cc. of tap water was then added to P.R. 2, C.W.L. 2, and C. 2, and 10* newly hatched larvæ were placed in each of the six beakers.

1st day :—No moults.

2nd day :—P.R. 1, all but one or two are now in their second skin.
P.R. 2, many are in their third skin; the remainder in their second skin, but further advanced than any of the P.R. 1.
C.W.L. 1, mostly in their second skin ; one at least is in the third skin.
C.W.L. 2, none past the second skin; all are distinctly behind C.W.L. 1.
C. 1, only two or three living larvæ to be seen ; these have just attained the second skin.
C. 2, all dead (probably due to the formation of a thick, greasy scum).

3rd day :—P.R. 1, none past the third skin.
P.R. 2, a number are in the fourth skin.
C.W.L. 1 and 2, do not differ noticeably from each other; both lots are behind P.R. 2.
C. 1, only one larva now living.

5th day :—P.R. 1, is still a long way behind P.R. 2.
P.R. 2, mostly full grown, but none have pupated yet.
C.W.L. 1 and 2, mostly full grown, but no pupæ yet.
C. 1, all the larvæ are now dead.

6th day :—P.R. 1, no pupæ yet.
P.R. 2, four have pupated.
C.W.L. 1 and 2, no pupæ yet, but the larvæ are casting the chitinous tube which contains the food within the gut.

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*The eggs from which these larvæ hatched had been kept dry for three weeks ; the larvæ emerged from them within one hour of immersion.

FINAL RESULT.

Lot.	Number of adults reared.	Time occupied from hatching to adult stage.			Mortality.	Remarks.
		Shortest.	Average.	Longest.		
P.R. 1 ...	5	10 days	12 days	15 days	50 per cent.	1 larva lived 34 days with abundance of food and then died.
P.R. 2 ...	4	8 ,,	9 ,,	11 ,,	60 ,, ,,	...
C.W.L. 1	9	9 ,,	11 ,,	14 ,,	10 ,, ,,	...
C.W.L. 2	6	9 ,,	10 ,,	11 ,,	40 ,, ,,	...

A comparison of these results with those obtained in Experiment No. XXVI. in respect of the larvæ fed on rice (P.R. 1 and 2), and those fed on leaves of the cottonwood tree (C.W.L. 1 and 2), brings out clearly the effect of scarcity of food on the one hand, and the possibility of water, overloaded with organic matter, being unhealthy if the larvæ are not numerous enough to cope with it, on the other.

In this experiment, as in No. XXVI., the advantage at the beginning between the pairs was again with the larvæ placed in the beakers where bacterial growth had the start; the final reverse of position between the pairs, though less marked, is still sufficiently in agreement to suggest that this is a real divergence and not a mere chance occurrence.

In the case of the pairs fed on cockroach (C. 1 and 2) the oily nature of the food material must be considered as chiefly, though not entirely, responsible for the ensuing mortality. For, even when the surface scum was broken up and a quantity of fresh water added, and these beakers produced some healthy adults, still the mortality was high.

Fifty larvæ which had emerged from their eggs an hour or two previously were added to beaker C 2, the covering of scum being broken up. They grew very slowly at first and there was a heavy death rate, but by the third day the survivors were making extraordinarily rapid progress and by the fourth day were in the fourth skin. All but one had pupated by the sixth day. Twenty-two adults were reared, eight within seven days; the average time being eight-and-a-half days, and the longest period between egg and adult eleven days.

A smear of the gut of a larva taken from this batch showed only two or three bacteria to a field, and one from a pupal gut was free so far as the microscopic test went; yet the water in which these larvæ were living swarmed with bacteria.

During the progress of Experiments Nos. XXVI. and XXVII. it became evident that the introduction of larvæ may have a remarkable clearing action on foul, cloudy water, if the conditions are properly balanced in respect of the number of larvæ and the quantity of water.

A test was made of the water from beaker C. 1. after the death of the last larva on the third day (the eighth day of the growth of the bacteria), the water showed an enormous bacterial infection, only

comparable with a broth culture. This water was put into a glass dish and diluted with four times its own volume of tap water, which rendered it less dense, but left it still cloudy; two hundred first skin larvæ were then placed in the dish, they grew with great rapidity, and as they progressed the water cleared, finally entirely losing all trace of its cloudy appearance.

The water in beaker C. 2 retained its thick, cloudy appearance *after* the development of the fifty larvæ above alluded to. It was decided to use this water for a further test regarding the clearing action of the larvæ.

A microscopic examination by wet films and stained smear (carbol thionin blue) showed the water to be swarming with bacteria—three forms predominating. One of these was a large and a very distinctive serpentine form. About one hundred first skin larvæ were added to the 200 cc. of foul water; they made very rapid progress. Two days later most of them were half grown, while the water had become quite clear. Microscopic examination showed a very marked reduction in the number of bacteria, with an entire absence of the large serpentine form.

Addendum.

Two beakers, in every respect similar to those used in the above experiment for P.R. 1 and C.W.L. 1, were prepared and stocked with the same number of larvæ.

Larvæ and pupæ were taken from these beakers at intervals and dissected, smears of the gut and its contents being fixed and stained in the same manner as sample drops of water. While the water in these beakers showed an identical infection with that in P.R. 1 and C.W.L. 1, in above experiment, the smears of the larval guts showed few, if any, bacteria to a field, and the pupal none at all.

Experiment No. XXVIII.

POSSIBLE RELATIONSHIP BETWEEN THE DEVELOPMENT OF BACTERIA AND THE GROWTH OF THE LARVÆ.

This experiment was a further attempt to solve the question of a possible relationship between the development of bacteria or other small organisms and the larvæ. The quantities of the different foods used were varied in the light of past experience in previous experiments.

On the 20th May, into four beakers, carefully cleaned and covered with thin cotton as in the previous experiments, were placed the following:—

Into G. 1 and G. 2 0·15 gr. of desiccated fragments of grasshoppers was placed.

Into C.W.L. 1 and C.W.L. 2, 0·5 gr. of desiccated fragments of fallen cottonwood leaves.

200 cc. of tap water was then added to G. 1 and C.W.L. 1.

On the 24th May, four days later, an examination of the water in G. 1 showed that it was thick and cloudy, while bacteria were present in immense numbers, three or four forms being especially noticeable :—

(1) A small, very short rod-shaped bacillus in dense clusters.
(2) Two forms (possibly of the same species) of large rods generally distributed but occasionally forming chains.
(3) Large serpentine forms scattered throughout the mass.

No paramæcium or rotifers seen.

C.W.L. 1, water clear but with fluffy patches. Bacteria less numerous, but still in great numbers. The large serpentine forms not present. A few paramæcium and a single specimen of a rotifer seen.

200 cc. of tap water was then added to G. 2 and C.W.L. 2.

16 newly hatched larvæ were placed in C.W.L. 1 and 15 in C.W.L. 2.

25 „ „ „ „ „ „ G. 1 and G. 2.

1st day (24 hours from start) :—

G. 1, a number have moulted.
G. 2, none have moulted.
C.W.L. 1 and 2, none have moulted.

2nd day :—G. 1, nearly all in third skin and mostly well grown in it ; one seen in first and one in second skin.

G. 2, a few (possibly one-third) in third skin, but the larger number in the second and two or three seen in the first skin.

C.W.L. There is not much to choose between C.W.L. 1 and C.W.L. 2 ; C.W.L. 1 has a few "stars" whereas C.W.L. 2 are more even in growth. Only one-fourth to one-third are in the third skin and these have only just attained it ; on the other hand, there are no second skin "laggards."

3rd day :—G. 1, 1 still in second and 1 in third skin ; the remainder are in their fourth skin, mostly full grown, but none have yet cleared the gut in preparation for the pupal stage. The water is now less cloudy than in G. 2.

G. 2, are very noticeably behind and have a higher death-rate. While most of them are in their fourth skin, and a few are as forward as G. 1, there are several that have only recently attained the third skin, and at least two are still in the second. Water very cloudy.

C.W.L. 1, about half are in their fourth skin and fairly grown, but slender (fat body ill developed) ; remainder in third skin. Water clear, brighter, and more deeply coloured than C.W.L. 2.

C.W.L. 2, are possibly a shade more backward than C.W.L. 1, but the difference is very slight.

4th day :—G. 1, after eight days, larvæ having been present for half the period, the water is nearly clear. Bacteria, though still plentiful, are in greatly reduced numbers. The serpentine forms and large rods are scarce, and there is also a marked absence of the dense clusters of the smaller bacilli.

G. 2, after four days, during which larvæ have been present all the time, the water is thick and cloudy, and there has been a considerable mortality. Bacteria are present in great numbers, but the large rod and serpentine forms are less numerous than they were in G. 1 before the larvæ were added. The most noticeable difference now is the absence in G. 1 of the dense clumps of short rod forms and their presence in G. 2.

C.W.L., the water in C.W.L. 1 is slightly darker than in C.W.L. 2, but both are clear and bright. There is, if very careful comparison is made, a trace of dulness in C.W.L. 1.

C.W.L. 1, shows very few bacteria, but much fluff, possibly cellulose fibre.

C.W.L., 2, shows a heavy infection compared with C.W.L. 1, mostly small forms with a few of the large chain-forming rods. No clusters and no serpentine forms.

Development of Larvæ.

G. 1, 1 pupa, 1 in second skin, 1 in third skin; remainder full fed (fat bodies developed), 22 living.

G. 2, no pupæ; no "laggards" (probably dead), only 13 living, all of which are full-grown.

C.W.L. 1, all in fourth skin, mostly full fed, 16 living.

C.W.L. 2, all in fourth skin, mostly full fed, 14 living.

5th day:—G. 1, 17 pupæ, 3 full fed larvæ, 1 just into third skin.

G. 2, 9 pupæ, 4 full fed larvæ.

C.W.L. 1, 4 pupæ, 10 larvæ, full fed.

C.W.L. 2, 4 pupæ, 14 larvæ, full fed.

Final Result.

Lot.	Number of adults reared.	Time occupied from hatching to adult stage.			Mortality.
		Shortest.	Average.	Longest.	
G. 1 ...	15 males, 7 females	6 days (10 males, 2 females)	6·5 days	8 days (2 females)	12 per cent.
G. 2 ...	11 males, 2 females	6 days (2 males)	7·1 ,,	8 days (3 females)	48 ,,
C.W.L. 1	10 males, 6 females	7 days (6 males, 1 female)	9·6 ,,	18 days (2 females)	Nil.
C.W.L. 2	5 males 9 females	8 days (1 male, 3 females)	14·8 ,,	24 days (1 female)	7 per cent.

After the emergence of the adults in beakers G. 1 and G. 2, on the 8th day after the introduction of the newly hatched larvæ, an examination of the water was made.

G. 1 appeared nearly clear; quite clear in comparison with G. 2. The bacteria present, though numerous, were relatively few in comparison with the conditions at the beginning of the experiment. Only occasional serpentine forms and single individuals of the large chain-forming rods were to be met with; very few clusters of the small short rods and such clusters when seen were small.

G. 2 was still swarming with large clusters of the short rods, while chains of the large rods and serpentine forms were numerous; the water being very thick and cloudy.

Sequel.

A fresh batch of 20 newly hatched larvæ were added to each beaker.

1st day (24 hours later):—G. 1, nearly all in second skin.
G. 2, all are in their second skin.

2nd day:—G. 1, mostly just into third skin, two or three in second and one or two in first.
G. 2, are all in third skin and mostly well grown in it; they are well ahead of G. 1 and the water is now nearly clear.

3rd day:—G. 1, mostly in third skin; two still in second and one in fourth skin.
G. 2, One in third, remainder in fourth skin—nearly all full fed.

4th day:—G. 1 and 2, compared, the water in G. 2 is yellower, but both are equally clear; as regards the development of the larvæ there is no comparison.
G. 1, are marking time in the third skin; only one has reached the fourth, and two remain very small in second or third skin.
G. 2, on the other hand, are all in the fourth skin; most of them with well developed fat bodies.

5th day:—G. 1, still marking time.
G. 2, 8 pupæ; remainder full grown.

Final Result of Sequel.

Lot.	Number of adults reared.	Time occupied from hatching to adult stage			Mortality.
		Shortest.	Average.	Longest.	
G. 1 ...	1 female	32 days	...	...	95 per cent. 1 larva lived until the 59th day and then died.
G. 2 ...	7 males, 9 females	6 days (2 males)	8 days	12 days (1 female)	20 per cent.

In view of the comments on Experiment No. XXVII. these last results scarcely call for any remarks; the experiment satisfactorily disposes of any remaining doubts as to the interaction of bacterial development and larval growth. The tentative suggestions put forward in the comments on Experiment No. IV., to the effect that bacteria took nutriment from the water which, even in the event of the larvæ devouring them, could not be regained, is confirmed by the results following the re-stocking of beakers G. 1 and 2 after the first broods had been reared. The success attending the careful adjustment of food to the quantity of water and number of larvæ also testifies to the correctness of the conclusions concerning these points in the comments at the close of the various experiments.

There seems little doubt but that the bacteria* themselves form a readily assimilable form of food for the larvæ, although, from the point of rigid economy, a certain wastage occurs unless the several factors are very nicely adjusted. This, however, in the terms of the case is likely to happen under natural conditions.

Experiment No. XXIV.

ABILITY OF THE LARVÆ AND PUPÆ OF *STEGOMYIA FASCIATA* TO SURVIVE COMPLETE SUBMERGENCE.

183 larvæ and 40 pupæ were placed in a wire gauze tube, 5 inches by 2 inches. The tube was then submerged in a large pan of water, the top of the tube being 2 inches beneath the surface. Some of the larvæ escaped through the 18 × 18 mesh of which the tube was constructed, and pupæ were also found outside, but these individuals may have escaped while yet larvæ.

After 20 hours an examination showed that 36 per cent. had escaped through the mesh. Of those which remained, 78 per cent. had been killed.

Pupæ— 3 living, 36 dead; mortality, 92 per cent.
Larvæ—28 „ 76 „ „ 73 „ „

No attempt was made to resuscitate the apparently dead.

Experiment No. XXV.

TEMPERATURE EFFECTS ON LARVÆ AND PUPÆ OF *STEGOMYIA FASCIATA.*

Heat.—Experiments were conducted in a tin pan about 6 inches in depth, holding 6,000 cc. of water with a surface area of 80 square inches, placed in the open on bare earth and exposed to the full heat of the midday sun during the latter half of November. These showed that both larvæ and pupæ could easily withstand such conditions, no mortality at all being observed. The test was commenced when the larvæ, from eggs laid in the pan by wild females, were half grown (after the second moult).

* Experiments which are now being performed in collaboration with Dr. E. E. Atkin prove that washed bacteria alone afford favourable food for the larvæ, and further suggest, though this is not yet definitely established, that the presence of living bacteria are essential to the development of the larvæ.

The temperature of the water taken on three successive days was as follows, care being taken that the thermometer was placed in the shade of the side of the tin :—

24th	November,	3 p.m.	... ...	101° F.
25th	,,	3 ,,	... ...	103° ,,
26th	,,	9 a.m.	... ...	75° ,,
26th	,,	3 p.m.	... ...	101° ,,

Larvæ and pupæ were taken from this pan with a quantity of the water and put into a beaker ; this was placed in a water bath and the temperature slowly raised. After 10 minutes the temperature reached 110° F., the pupæ remaining active, but they all kept close to the surface. Between 112° and 115° F., reached within 15 minutes, both larvæ and pupæ died.

Larvæ from the pan were treated similarly, but the course of the experiment was interrupted ; the moment the thermometer registered 112° F. the beaker was removed from the bath and allowed to cool. All the larvæ seemed to be in difficulties ; most of them remained at the surface, but a few continued to show slight activity at the bottom. 20 hours later, the water having fallen to the laboratory temperature of 80° F., about one-third to one-half of the larvæ had recovered their activity or had pupated, the remainder were either dead or dying. The survivors nourished upon the dead bodies of their comrades successfully completed their development, producing adults which, so far as outward appearance was concerned, were normal.

From this it would appear that the upward limit of temperature is in close agreement with that for other insects, as shown by Blacklock (1912) with bugs and Bacot (1914) with bugs, fleas and cockroaches.*

Cold.—A number of larvæ and pupæ were taken from various breeding pans in which the water temperature was in the neighbourhood of 80° F.

The beaker to which they had been transferred was placed in the ice chest and cooled to about 74° F. ; this change did not affect the insects at all. It was then placed on a block of ice ; after one hour the temperature of the water had fallen to 49°–50° F. All the pupæ remained active, and one adult (a female) had emerged ; about half the larvæ, including both small and large, had fallen to the bottom stiff and immovable, to all appearance dead. After a further two hours on the ice the temperature had fallen to 40° F., and all the larvæ were in stiff and stretched out positions at the bottom ; while all the pupæ, with one or two exceptions, were immobile and lax at the surface. The beaker was removed from the ice and the temperature allowed to gradually rise. At 60° F. all the pupæ had regained their full activity, but the larvæ showed no signs of recovery until the temperature rose to 70° F. An hour later, when the temperature had reached 80° F., nearly all the larvæ had recovered their activity.

Next day.—6 larvæ and 2 pupæ were dead out of 40 larvæ and 24 pupæ submitted to the test ; 6 adults had emerged from pupæ ; from the remaining larvæ and pupæ 47 adults were reared.

The female which emerged from the pupæ while the beaker was on ice was placed in a box and put on the ice beneath the blanket. After two hours she showed no effect from the cold beyond being slightly sluggish. After twenty-four hours she was still living and active. The melting of the ice prevented a continuance of the test.

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* Adults of *S. fasciata* are quickly killed at a temperature of 50° C.

Experiment No. XXXI.

SURVIVAL OF LARVÆ OF *STEGOMYIA FASCIATA* ON WET FILTER PAPER.

A larva in its fourth skin was stranded on a piece of filter paper ; after one hour's drying the paper had become stiff and dry. The larva was shrunken in appearance and incapable of movement. The small piece of paper on which it lay was snipped off and returned to the water. The larva lived and remained active for 44 hours, during which period it could not get to the surface for air, owing to one of its gills being stuck to the paper.

Two pupæ and two larvæ were found stranded on wet mud at the bottom of a half cocoanut shell. They were removed to wet filter paper and placed in a moist cell. Within twenty-four hours both the pupæ had developed and adults emerged, but failed to finally free themselves from the pupal envelope. One larva died after three days, the other lived for ten days, during which period, although kept wet, it was unable to move

Experiment No. XXXII.

ENEMIES IN THE LARVAL STAGE.

MacGregor, in his notes with reference to the *breeding of *Stegomyia fasciata* in London, states that the young larvæ are consumed by the larger ones. The high rate of mortality among newly hatched larvæ placed in breeding pans which were already stocked, or had been previously used for breeding, was noticed early in the course of the results at Freetown, but the cause was not determined. Cannibalism among larvæ of the same age, though watched for under starvation conditions, was never detected. What appeared to be a flagrant case proved, on close observation with the binocular dissecting microscope, to be two fully grown larvæ, one half-grown and a very small one, with their jaws hopelessly entangled in a small mass of silk or hairs, probably a fragment of some insect cocoon. To the unaided eye the presence of the smallest larva was not apparent, and appearances suggested that two full-sized larvæ were attacking a smaller one. After watching half-an-hour's vain struggles, a few moments' aid with dissecting needles set all four free.

Larvæ and pupæ which died in breeding jars and pans where food had been purposely cut down to a minimum were noted as being untouched until the process of decay set in, when they soon disappeared, and a spurt by one or more of the survivors suggested that the nutriment set free had been absorbed, even if the carcase had not been eaten piecemeal.

Experiments carried out in London after my return home confirm MacGregor's observation. Newly hatched larvæ when about to moult are apparently devoured by those which have attained their fourth instar, but it

* "Journal of Tropical Medicine and Hygiene," Sept. 1st, 1915; No. 17, Vol. XVIII., pp. 193-6.

is questionable if danger results from the presence of third instar larvæ. A single third instar larva was placed in a pan with 9 newly hatched ones; after three days, no food being present, 8 living and 1 dead larvæ were present in the pan, in addition to the third instar larva.

Result, negative.

6 newly hatched larvæ were placed in a glass pan with 5 larvæ in their fourth skin. After 24 hours all the young larvæ were present, some of them having moulted.

23 more newly hatched larvæ were added to the pan and 7 more fourth skin larvæ, so that the numbers stood at 12 fourth skin and 29 young larvæ, mostly newly hatched.

After 48 hours all the young larvæ were still living and one of the fourth skin larvæ had pupated.

After 72 hours the young larvæ were still living.

After 96 hours the young larvæ were still living, and were many of them in their fourth skin, while several of the fourth skin larvæ had pupated.

Result, negative.

A fresh trial was made with—

51 newly-hatched larvæ and 20 fourth skin larvæ, in various stages of growth. The pan was of the same size as in the previous experiment. After 20 hours only 35 of the newly-hatched larvæ could be found, 31 living and 4 dead—a mortality of 31 per cent. = a ratio of four-fifths to each fourth skin larva. Of the living larvæ 13 had attained the second skin.

Result, positive.

40 larvæ that had completed their first moult were then placed in the pan with 22 larvæ in their fourth skin.

After 48 hours all the second skin larvæ were still living, a number having moulted for the second time.

Result, negative.

12 newly hatched larvæ were placed with 5 in their fourth skin into a small glass dish.

After 48 hours there were only 10 of the small larvæ present and 1 of these was dead, a loss of 16 per cent. = a ratio of two-fifths to each fourth skin larva.

Result, positive.

Test in filtered Manure Water.

200 newly-hatched larvæ were placed with 20 fourth skin larvæ in various stages of growth.

After 24 hours only 176 of the young larvæ could be found, a loss of 12 per cent. = a ratio of $1\frac{1}{5}$ newly-hatched to each fourth skin larva.

Result, positive.

88 newly-hatched larvæ were placed with 4 in their fourth skin.

After 24 hours only 82 of the young larvæ could be found, a loss of 7 per cent. = a ratio of $1\frac{1}{2}$ to each fourth skin larva.

Result, positive.

70 newly-hatched larvæ were placed with 10 in their fourth skin.
After 24 hours only 68 of the young larvæ could be found, a loss of 3 per cent. = a ratio or $\frac{1}{5}$ to each fourth skin larva.
Result, positive.

Test in clean Tap Water.

110 newly-hatched larvæ were placed with 16 in their fourth skin.
After 18 hours only 106 of the young larvæ could be found, a loss of 4 per cent. = a ratio of $\frac{1}{4}$ to each fourth skin larva.
Result, positive.

179 larvæ in their first skins, most of which had just emerged from the egg, were placed with 20 in their fourth skins.
After 24 hours all the young larvæ were present but 3 were dead.
Result, negative.

332 newly-hatched larvæ were placed with 14 in their fourth skins.
After 18 hours only 316 of the young larvæ could be found, a loss of 5 per cent. = a ratio of $1\frac{1}{2}$ to each fourth skin larva.
Result, positive.

A number of dissections were made of the fourth skin larvæ used in the above tests and also of fourth skin larvæ in various stages of growth which had been kept for from two or three hours up to a day or longer in jars of water with large numbers of newly-hatched ones. No remains of small larvæ, however, were traced in either stomach or intestine. Close observation on several occasions revealed no cases of ingestion and no desire or attempt was ever evinced by large larvæ to catch the small ones. Even under such crowded conditions that accidental ingestion seemed inevitable the act was never witnessed. The sole direct evidence of ingestion obtained was the head capsule of a first skin larva recovered from fæces passed by a fourth skin larva. The conditions under which this was found, however, preclude it being a case of the swallowing of a cast skin unless it had remained in the gut for two or more days, as none of the young larvæ had moulted during the period of the experiment.

On the whole the evidence (especially the frequent finding of *dead* first-skin larvæ in containers in which fourth skin larvæ are present) seems to point to the devouring of the young larvæ by the larger ones being a matter of chance. There remains, however, the possibility that cannibalism is a variable habit occurring in a few larvæ or certain strains of the insect only.

It seems therefore that the fourth instar larvæ may be themselves among the most formidable agents in the destruction of their species. The habit of breeding in small collections of water, while saving the species from a death toll by other enemies, enhances the opportunities and danger of fratricide. The action of the two habits, together with the intermittent hatching of the eggs, will be that of a sliding scale to keep the adult population at a comparatively even level. It will be a matter of some interest to see if the same habit of fratricide obtains in other species.

Apart from either competition or fratricide, breeding in small scattered collections of water largely precludes the action of predatory enemies during the larval stage of this species. Ducks, if free to roam about the precincts of the dwelling, will doubtless do an enormous amount of useful work; they will, however, destroy other predatory enemies of mosquitoes,

such as frogs, dragon fly larvæ and water beetles, which may be present in the larger pools, without discrimination. This does not seriously militate against their services, however, as most of the larger predatory insects, at any rate, are likely to have a wider range than mosquitoes, and will tend to rapidly repopulate from outside the areas cleared by ducks.

Fish, which are of great value in holding in check species of mosquitoes which breed in permanent pools or streams of water, are likely to be of small value as enemies of *S. fasciata*, although species with similar habits to those of carp and tench might be utilised in water butts or cisterns.

Tadpoles, as stated by Stephens and Christophers (1908) and other authors, do not attack mosquito larvæ, though they probably have a checking influence owing to competition in the matter of food supply. Direct experiment proved that even in a crowded jar there was no mortality to well grown mosquito larvæ, transformation to the adult stage taking place as usual. It is possible, however, that the small larvæ undergoing the first moult might be engulfed.

A small water-bug belonging to the *Micronecta* was found in very small rock pools with larvæ of *S. sugens* and *Anopheles costalis*. In captivity it attacked and sucked the juices of larvæ of *S. sugens*. Its power of flight would enable it to transfer itself from pool to pool if scarcity of food or drought rendered them untenable, but the species was never seen in sufficient numbers to warrant the supposition that it would do more than take a moderate toll of the larvæ it fed on.

The presence of a species of *Ostracoda*, probably belonging to the genus *Cypris*, in breeding pans or jars appears to be inimical to mosquito larvæ. This seems to be due to competition in respect of food solely, as the larvæ (*S. fasciata*) added to water containing the *Ostracoda* live for a longer or shorter time, but seem unable to proceed with their development, few, if any, succeeding in attaining the adult stage. A similar phenomenon has been noted in England with regard to *Culex pipiens*—small pools in Epping Forest which were populated with a minute crustacean being free of mosquito larvæ.

(C) ADULTS.

General Notes.

Pairing and feeding with *Stegomyia fasciata in captivity* are not restricted to any particular period of the day or night. No doubt if an accurate census could be taken, the late afternoon or evening might be found to be the most favoured period, but when numbers of recently emerged specimens are placed in a cage pairing commences almost immediately, and feeding, on the part of a proportion of the females, at the earliest opportunity.

There seems to be no regular precedence of one or the other function, but females heavy with blood are too sluggish to pair and tend to rest low down in the cage, or even on its floor. Anything less than a full meal only slightly impairs their activity and pairing proceeds as usual. If the initial meal of blood be interrupted they will feed again within the next few minutes, satiety being evidently instinctively aimed at.

Feeding.—The effect of drought as a deterrent to feeding was very noticeable, both in the cages within doors and especially in the mosquito house out of doors.

In the cages, both by day and at night, the harmattan periods did not interfere with feeding and egg laying to any extent, because the time allowed for feeding was ample, but in the mosquito house, where the visits were of short duration, the effect of dry periods was much more noticeable. In place of the surging swarms which usually rushed on their prey, only a few individuals put in an appearance to feed on my entrance. Within a few minutes, however, the insects issued from their hiding places and commenced to attack. The evidence as a whole suggests that, while the dry air is the cause of retirement to any available shelter from the wind, it is not disinclination to feed that prevents the mosquitoes biting so readily, but failure to recognize the presence of a host. Probably it is the absence of odour which delays attacks in dry weather. The bites, if numerous, have the effect of inducing a profusion of perspiration, especially in warm weather and before one becomes thoroughly inured to their attacks, while the free flow of perspiration seems to attract the insects.

Pairing commences during flight, but is usually consummated while at rest, and occupies but a few moments at most. The position when the pair have settled varies considerably. A tail to tail position was observed, but is rare; side by side, with bodies tilted at an angle to each other and the surface on which they are resting is not uncommon, but the usual position seems to be for the male to embrace the female and underlie her with his back to the resting surface.

General observation suggests that the same female, possibly the same pair, copulate several times in quick succession, but no experimental proof of this was obtained when a single pair were segregated.

Captive females refuse to suck blood for some hours, in most instances for at least a day, prior to egg laying, and, if the bulk of their egg masses are not extruded on the first night, they will not as a rule feed again until after the deposition of the remaining eggs. Evidence is afforded by the record of the female used in Experiment No. IX. on page 34.

Vigorous females almost invariably feed within twenty-four hours after clearing their ovaries of mature eggs, and on the following day as well. On the third or fourth day they usually abstain, a fresh batch of eggs having developed. Weak or elderly females are much more erratic, both as to feeding and the deposition of eggs. There is direct evidence in Experiments Nos. XLI. and XLII. of the retention of eggs for considerable periods by some females. The proportion exhibiting the habit is not large, and the period of retention is variable; while it is possible that further meals of blood would have induced some of these females to deposit their eggs earlier, it is to be noted that the habit was observed in a few instances in the case of females which were afforded nightly opportunities of sucking blood. Probably the habit affords evidence of a more or less latent instinct, connected with æstivation, which preceded the evolution by the various species of *Stegomyia* of eggs so perfectly adapted to resist drought as those which are now produced.

A single full meal of human blood was found to be sufficient for the development of the ovaries. Eggs were deposited in many instances after a single meal of blood, and trial showed that these eggs were fertile.

Females fed on a goat, dogs, a ground pig (Bandicoot) and wild rats *(Mus rattus)* also developed their ovaries after a single meal of blood from these animals. In the case of those fed on *Mus rattus*

trials were carried out to see if the eggs were ripe for deposition. A female was placed in a jar with wet filter paper and, after the lapse of a few days, deposited a batch of eggs which, after incubation, hatched within a few minutes of their immersion.

The laying of eggs on any diet other than circulating blood is a rare but not unrecorded phenomenon. Otto and Neumann (1905) succeeded in obtaining fertile eggs when the females had been fed on blood and salt solution. Two instances occurred in the course of the present research of single eggs being laid by females that had no opportunity of feeding on a living animal. In one case the females were fed on blood mixed with honey, in the other on blood mixed with syrup. In the latter instance the egg proved to be fertile. These foods were chosen with the special object of testing the practicability of breeding without allowing them to feed on a living animal, as the practical advantage of such a method would be very great. In the face of the extreme rarity of egg-laying under the conditions, however, the experiments must be considered as failing of their purpose.

Eggs were only deposited when water or saturated surfaces were available. An experimental test (No. XLIII.) carried out with a view to confirm this general observation resulted in a single infertile egg being laid by one of thirty-nine regularly fed and presumably fertilized females.

Length of Adult Life.

It is impossible to ascertain the length of life of adult mosquitoes under natural conditions. Even under semi-natural conditions the difficulties are great and increase just in proportion as nature is simulated.

The larger the containing cage, the greater the difficulties of counting and obtaining any exact figures of the mortality, while reduction in size leads to difficulties in feeding and the introduction of specimens.

In either case a small mesh netting (18 × 18 to the inch for *S. fasciata*) must be used to obviate escape; this greatly militates against a free draught of air, and in the case of small confining chambers it becomes only practicable to record the temperature and humidity in the immediate vicinity exterior to such cages.

Probably, while the shielding afforded by captivity tends to reduce the general mortality, no artificial conditions can be arranged so favourable to the exceptionally long-lived and lucky mosquito as those obtaining in freedom.

The ability to shift its resting place to meet the needs of every change of humidity or temperature both daily or hourly is an asset which is reduced to such narrow limits by captivity as to be all but valueless.

Two plans were followed to obtain feasible results in this research ; the one of confining 50 or 100 adults in wire gauze cylinders $4\frac{1}{2}$ ins. × 2 ins., the other of keeping them in the convenient cage that can be made out of a large sized hurricane lamp chimney, the top covered with fine gauze while the open lower end is placed downwards on a pad of either dry or wet filter paper placed in a wide shallow tin lid.

The first method allowed of the nearest approach to natural conditions of drought or humidity, it was possible to devise with the object in view, while the latter afforded a more favourable way of testing the effect of different foods, egg-laying, etc. The wire gauze tubes were placed in a variety of situations but the necessity of making use of some device to prevent the ants reaching them considerably limited the possible range.

Mosquitoes were allowed to emerge direct into the tubes, a plan that avoided much waste of time and allowed of accuracy in respect of their age, but had the disadvantage that records of sex and numbers could only be accurately ascertained after their death. The sex has been recorded wherever possible, but when the insects were placed in damp situations the remains were frequently too mildewed or decayed to admit of their sex being discriminated ; while in some instances the actual numbers after the mid period of the experiment are approximate only, owing to the same causes. Such situations as the Well in the Sanitary Department Compound, the Pit in the Mosquito house, and, in some cases, the Yard at 26, Westmoreland Street, led to trouble in this respect.

Ants were responsible for the wrecking of a number of experiments and caused both waste of time and effort, while the rotting through of the cord or rope used to lower the tubes and isolation pan down the well was a source of annoyance.

In all the experimental records the period of life tends to err by the length of the period between each examination. In every case the extreme has been taken, the mosquitoes being assumed to have lived up to the date on which they were found to be dead. In most cases the examination was daily, but in the Pit it was occasionally every other day, while in the Well only two examinations a week could be made, so that the error might amount to three or four days.

It will be safe, therefore, to assume that the lives recorded are the limits under the particular conditions involved.

Without food the adult life, under favourable conditions, although short, is by no means inconsiderable for so small and active an insect, an average of 6 to 8 days, with an extreme of 12 days, being recorded. This compares favourably with the records in which food was given in less suitable situations. It would appear to be a general rule that the environmental conditions are more important than the food; honey and syrup given under moist conditions giving a longer average life than blood under dry ones. Another point which the budget of record shows is that the kind of food given makes far less difference to the average length of life than it does to that of the exceptionally long lived individuals.

The second plan was used in the attempt to ascertain the extreme age limit under favourable conditions when fed on various foods.

Hurricane lamp chimney cages were also employed in the experiments dealing with egg production on a single meal of blood and the attempt to induce egg-laying by giving a mixture of blood, either fresh or dried, with honey or syrup as food. The air in these cages would be still, if not stagnant, so that the use of a dry, in place of a wet filter paper, as a base in some of the trials, would not necessarily cause a drying atmosphere, though of course it would be dry if compared with the saturated conditions which obtained when the base rested on wetted paper and the gauze top was covered with a piece of glass. All the experiments in which these lamp chimney cages were used were carried out at the quarters in Westmoreland Street, so that the working room temperature and humidity chart applies to all of them.

In the second series the advantages of moist over drier conditions are far less apparent, in fact, the suggestion is rather that humidity may be in excess of what is desirable from the mosquito's point of view. This impression is, however, partly due to an accident causing a high concentration of the syrup given as food in one of the experiments, and also to the fact that a number of the insects got their legs into a sticky condition, and this apparently raised the death rate at an early period of the experiment. On the whole, syrup gave a better result than honey, possibly because it was more fluid. Banana, again, gave less favourable results than either honey or syrup; this may also be owing to the fluids in the over-ripe fruit being less easily obtainable than syrup from cotton-wool. The longest female lives recorded in the series are of those

fed on a mixture of blood and syrup or blood and honey. The average ratio of life of the males in comparison with that of the females would seem to be from about 3 to 5 or 2 to 3.

An experiment (No. XLIII.) carried out with the double object of ascertaining if the females would lay eggs apart from water or wet surfaces, and their length of life when well fed on human blood under these conditions, shows that such circumstances are not detrimental to longevity, the average life of 31·3 days, with an extreme of 74 days, comparing not unfavourably with that recorded when they are afforded opportunities of oviposition.

Experiment No. XXXIII.

CHOICE OF SITUATION FOR OVIPOSITION BY FEMALES OF *STEGOMYIA FASCIATA.*

At an early stage of the research trials were commenced to see if ovipositing females lay their eggs in any receptacle containing water without reference to its situation or if, as is commonly stated, they show a preference for certain rooms or positions. Various utensils containing water were placed in the basement, outbuilding, yard, living room, bedroom, etc., in the quarters at 26, Westmoreland Street.

A careful search was made every three or four days for a month. The record is as follows:—

Bedroom.—1 larva, *S. fasciata.*

Bathroom.—A few larvæ and ova of *S. fasciata,* also a batch of eggs of *Culiciomyia nebulosa.*

Covered Wooden Gallery (containing pantry and sink where the "boys" wash up).—A few eggs and larvæ of *S. fasciata.*

These latter occurred in a water pan in which one of the legs of the safe was placed. It is possible that they resulted from eggs left over from the previous tenancy. The *basement*, *yard*, *kitchen*, *store-room*, *dining-room*, and *living-room* were all negative.

This preliminary trial was followed by another, covering the month of October, in which new card cream jars of one pint capacity were used, the jars being half full of filtered rain water. The situations were as follows:—

Bedroom.
Dining-room.
Sitting-room.
Store-room.
Hall.
Basement fronting on the street, kept closed but opening on the yard through an unglazed window.
Gallery with pantry and sink.
Kitchen.

Bathroom.
Room beneath bathroom where the house boy slept.
Cellar beneath kitchen.
Yard.

Careful search for eggs and larvæ was made every three or four days (twice a week).

Result.

Only the jar in the kitchen was visited. The water in this jar became very thick and foul owing to dust, dirt and insects falling in. Numbers of eggs of *S. fasciata* were laid in it. Although the jar in the gallery was not visited two of the water pans in which the legs of the safe stood had eggs laid in them, and a jar of water in the sitting-room in which some cut plants were placed also received the attention of an egg-laying female. The small jar placed in the yard was not visited, but a large tin bowl, put out with the object of getting a supply of rain water, was, and soon produced numbers of larvæ of *S. fasciata*, among which were some of *Eretmopodites quinquevittatus* and *S. luteocephala*.

In the mosquito house a wooden tub, several tin pans, and basins, and a new galvanized iron pail were used. Both the tins and wooden tub were favoured; the pail was avoided, and several successive lots of larvæ put in died off almost immediately.

It was not until after the pail had been twice thoroughly scrubbed out with soap and water, and allowed to stand in the sun for a week, full of rain water, that it became a possible breeding place for *S. fasciata*. Altogether, with the various tests in between the scourings, etc., it took a matter of six weeks to two months before the pail was serviceable for breeding purposes.

Experiment No. XXXIV.

BAITS TO ATTRACT PREGNANT FEMALES.

The perusal of minute Ref. C.O. 51,476, 24th December, 1914, together with the attached papers concerning a mosquito trap suggested by Dr. E. Peter, of Duala, Kameroons, led to further experiments designed to throw light on the extent to which ovipositing females select water contaminated with organic matter in preference to clean.

1st Trial.—A number of freshly emerged *S. fasciata* were put into a large cage. Honey was supplied for the males while the females were afforded ample opportunity of imbibing human blood every night.

Two beakers, each containing 200 cc. of tap water, had six slips of filter paper arranged with one end in the water and the other turned over the rim.

In one, *A*, nothing was added, in the other, *B*, two dead grasshoppers were placed. Both were placed in the cage containing the mosquitoes, and their relative positions were reversed during the course of the experiment.

After five days the water in *B* was cloudy and thick with a scum on the surface; it also smelt badly. The water in *A* was not appreciably less clear than at the start.

In *A*, 62 eggs (14 per cent. of the total) were laid on the filter paper at various distances between water level and one inch above it, mostly about midway up.

In *B*, 392 eggs (86 per cent. of the total) were laid, 28 on the surface scum, the remainder on the filter paper over a much wider area above water level than in *A*.

2nd Trial.—Into the same cage three beakers prepared as previously were placed.

Into *A*, tap water only.
Into *B*, 1 cc. of sheep's bile that had been kept for three months.
Into *C*, ·5 gr. of Bile Salts (Sodium Taurochlorate).

After two days in the cage eggs had been deposited as follows:—

A. 58 eggs on the filter paper 7 eggs on the glass or water surface	65 eggs = 23 per cent. of the total laid.
B. 71 eggs on the filter paper 29 eggs on the glass or water surface	100 eggs = 35 per cent. of the total laid.
C. 99 eggs on the filter paper 20 eggs on the glass or water surface	119 eggs = 42 per cent. of the total laid.

3rd Trial.—Four beakers were prepared as previously.

Into *A*, tap water only.
Into *B*, ·5 gr. of dried and powdered cockroach.
Into *C*, ·5 gr. of dried and powdered leaves of cottonwood tree.
Into *D*, ·5 gr. of dried crushed rice.

The beakers were then placed in an incubator at 95° F. for 24 hours and then put into the cage with the mosquitoes for two days, their positions being changed about after the first day.

After two days in the cage eggs had been deposited as follows:—

A. 418 eggs on the filter paper 15 eggs on the glass or water surface	433 eggs = 26 per cent. of the total laid.
B. 667 eggs on the filter paper 120 eggs on the glass or water surface	787 eggs = 48 per cent. of the total laid.
C. 160 eggs on the filter paper 28 eggs on the glass or water surface	188 eggs = 12 per cent. of the total laid.
D. 231 eggs on the filter paper 6 eggs on the glass or water surface	237 eggs = 14 per cent. of the total laid.

In all 1,645 eggs were laid.

The water in *B* had a whitish surface scum and smelt badly. In *C* it was pale brown and smelt rather like weak tea. In *D* it was thick and cloudy without any noticeable smell.

While the evidence of selection in all three trials appears definite, it is very far from being of the unanimous unvarying character that might be expected from a deep seated instinct coupled with larval needs. On the contrary, it carries with it a certain suggestion of bias on the part of the females in reference to their own tastes, largely parallel but not necessarily identical with provision for their offspring; otherwise, why the neglect of the suffusion of leaves, possibly bitter, and rice water, possibly sour, either of which would afford better chances for larval development than plain water?

Experiment No. XXXV.

LENGTH OF LIFE WHEN CONFINED IN WIRE GAUZE TUBES UNDER VARIOUS CONDITIONS.

In considering the relative length of life as recorded in the various trials, the situation as well as temperature and humidity must be borne in mind, as local conditions have a quite considerable influence on the amount of drought and circulation of the air.

Charts recording the temperature and humidity in the various places where the tests were made, follow the descriptions of these situations. In addition, a chart compiled from the official Meteorological Report of the 9 a.m. readings at the Freetown Meteorological Station is appended as a guide to the general conditions obtaining during the months that no records were taken in the various trial situations. The record for the well only covers the actual periods of the tests and is not translated into a curve.

A partial record of the maximum and minimum temperatures and weekly extremes is also appended. This covers the period from September 11th to December 4th in the laboratory, from December 4th to February 27th in the animal house, and from February 27th to July 31st in the mosquito house, and affords some idea of extremes registered in these three situations. As only one registering thermometer was available, it was a matter of choice between one complete or several partial records.

A record of temperature and humidity in the laboratory is included in the "General Notes" prefacing the larval section.

Yard at Quarters, Westmoreland Street.—This was small, overhung by trees, surrounded on three sides by buildings and on the fourth by a high wall. No weeds were present on the small plot of soil where the pen was fixed. On the whole a cool, moist, favourable situation. (*See* page 92).

Cage in Quarters, Westmoreland Street.—This stood on a table about 4 feet from the ground on the first floor facing the stairway. This situation was dark, a few gleams of late afternoon sunlight being the most that ever penetrated to the cage, but, on the other hand, it was well ventilated. (*See* page 93).

Compound at the Hospital.—The pen was placed in an open, sunny spot, slightly shaded at midday by eucalyptus trees. The insects confined here were subjected to greater extremes of heat and drought than in any of the other situations. (*See* page 94).

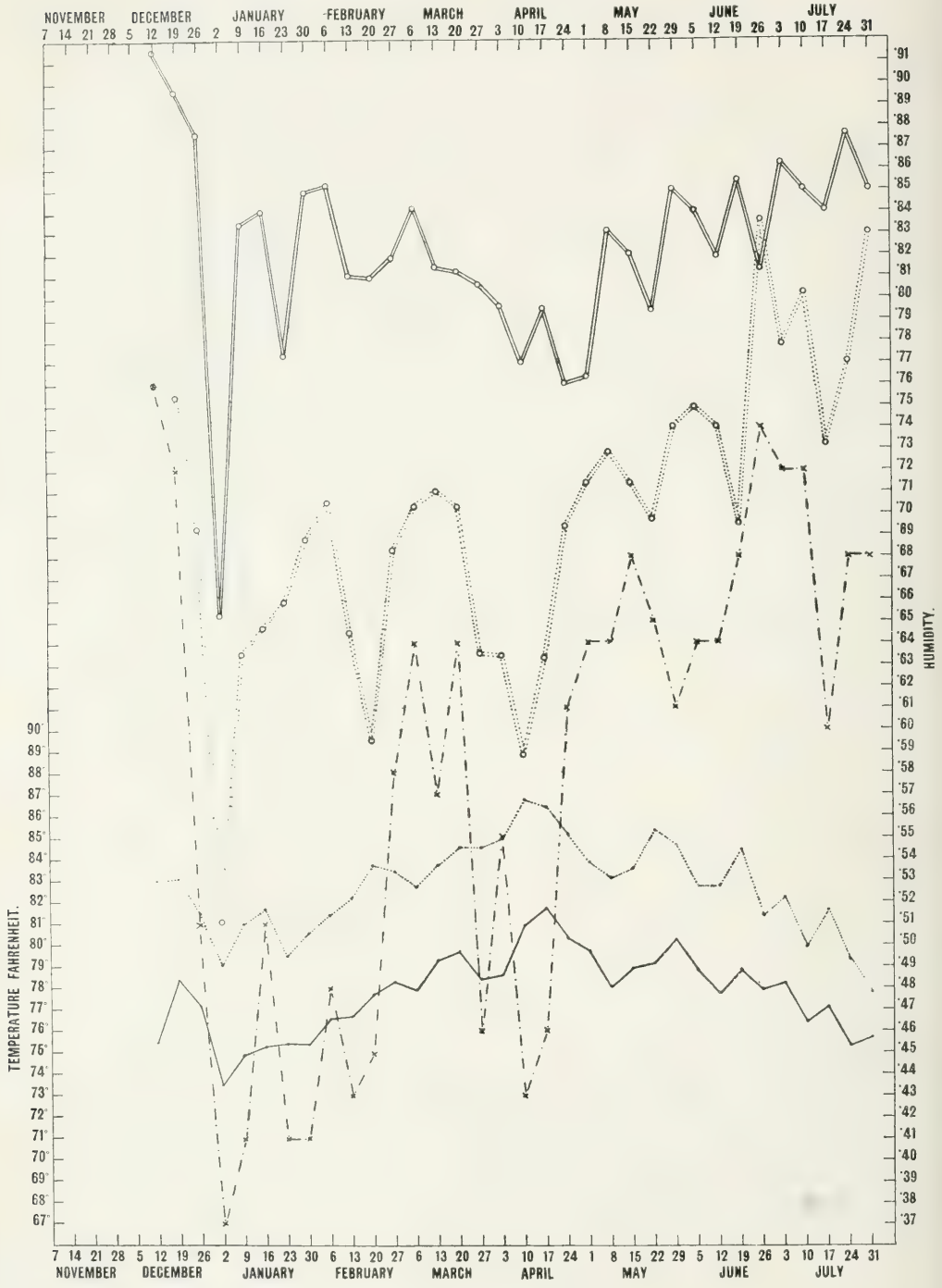
Animal House.—(Plate No. 20, page 96). Darker, cooler and less well ventilated than the cage at quarters in Westmoreland Street. The air would also be cooler and more moist at night. (*See* page 95).

Mosquito House.—(Plate No. 21, page 96). This was sheltered under a small but densely leaved tree and also by a tall shrub. It was shut in on east and south by buildings and on the west by a high wall a few yards distant from it. On the north it was exposed, but obtained some shelter from two small trees about ten yards away. On the whole, a shaded situation tending to be both cool and moist. (*See* page 97).

Mosquito House Pit.—The pit within the Mosquito House was two feet by two-and-a-half feet in area, and two feet deep, lined with rough planks. It was covered by a wooden lid, which left an open crack half an inch wide. This situation was very dark, ill-ventilated and humid. (*See* page 98).

Chart No. 2.

Curves of Temperature and Humidity in Yard at 26, Westmoreland Street, Freetown, Sierra Leone.


NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY
7 14 21 28 5 12 19 26 2 9 16 23 30 6 13 20 27 6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 3 10 17 24 31
TEMPERATURE FAHRENHEIT.
HUMIDITY.

Observations made at 7 a.m. and noon each day:—

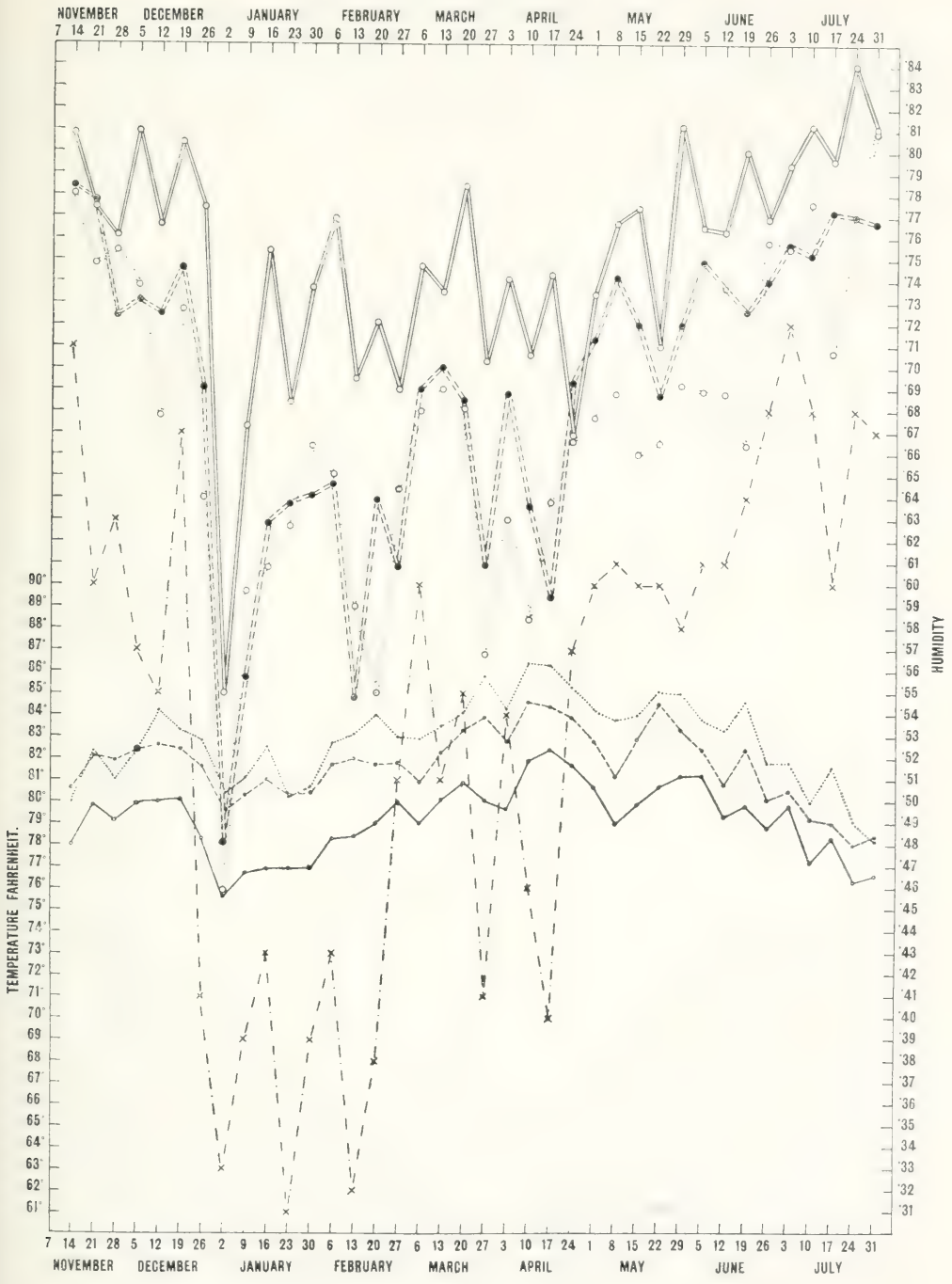
Temperature ———— 7 a.m. Humidity ═══

„ . . . . . Noon „ : : : : : : : : : : :

Minimum Humidity records in each week — · — · — · — ·

Chart No. 3.

Curves of Temperature and Humidity in Working Room at 26, Westmoreland Street, Freetown.


NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY
7 14 21 28 5 12 19 26 2 9 16 23 30 6 13 20 27 6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 3 10 17 24 31
TEMPERATURE FAHRENHEIT.
HUMIDITY

Observations made at 7 a.m , Noon, and 7 p.m. each day :—

Temperature ——————— 7 a.m. Humidity ═══════

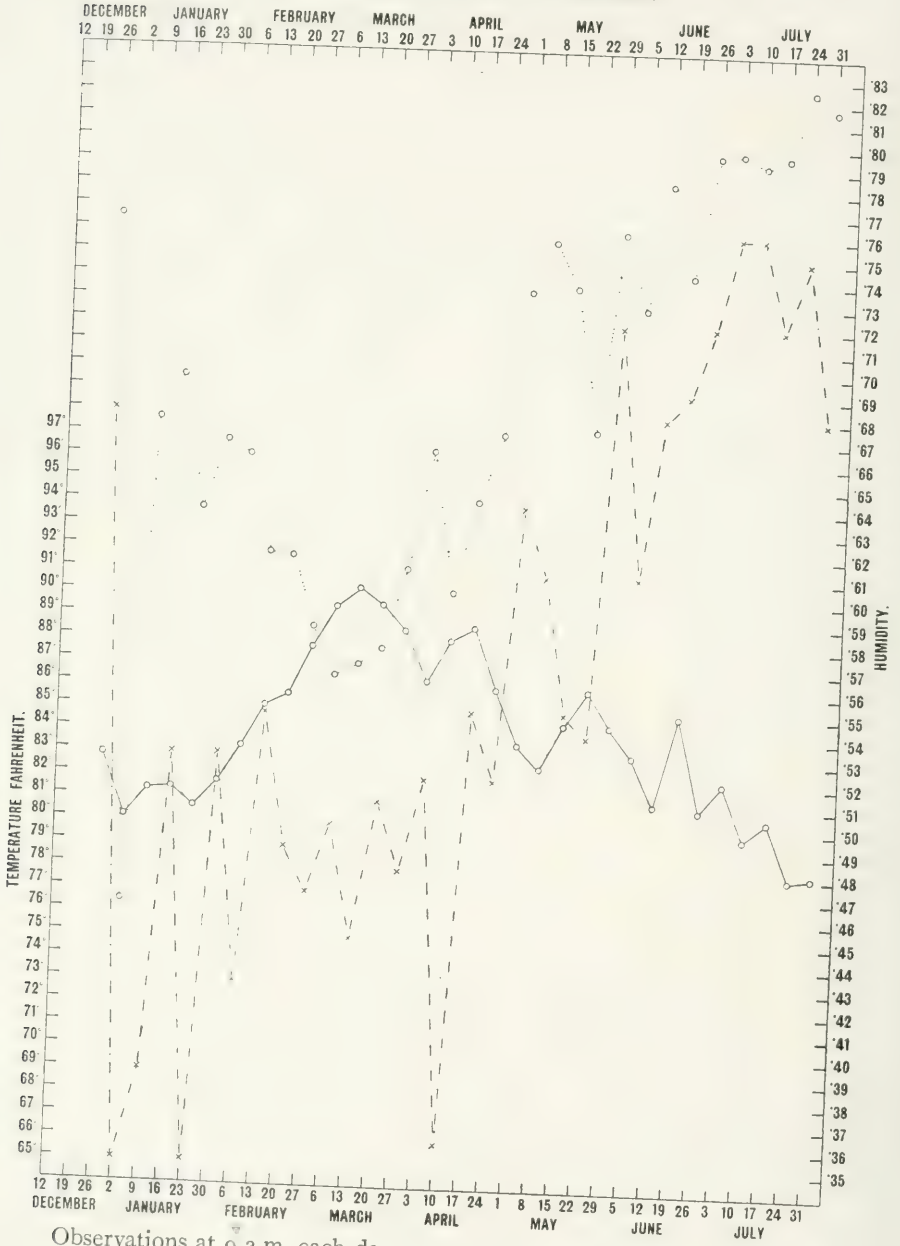
,, ... Noon ,, : : : : : : : : : : : :

,, – – – – – – – – – – 7 p.m. ,, ==========

Minimum Humidity records in each week — · — · — · — ·

Chart No. 4.

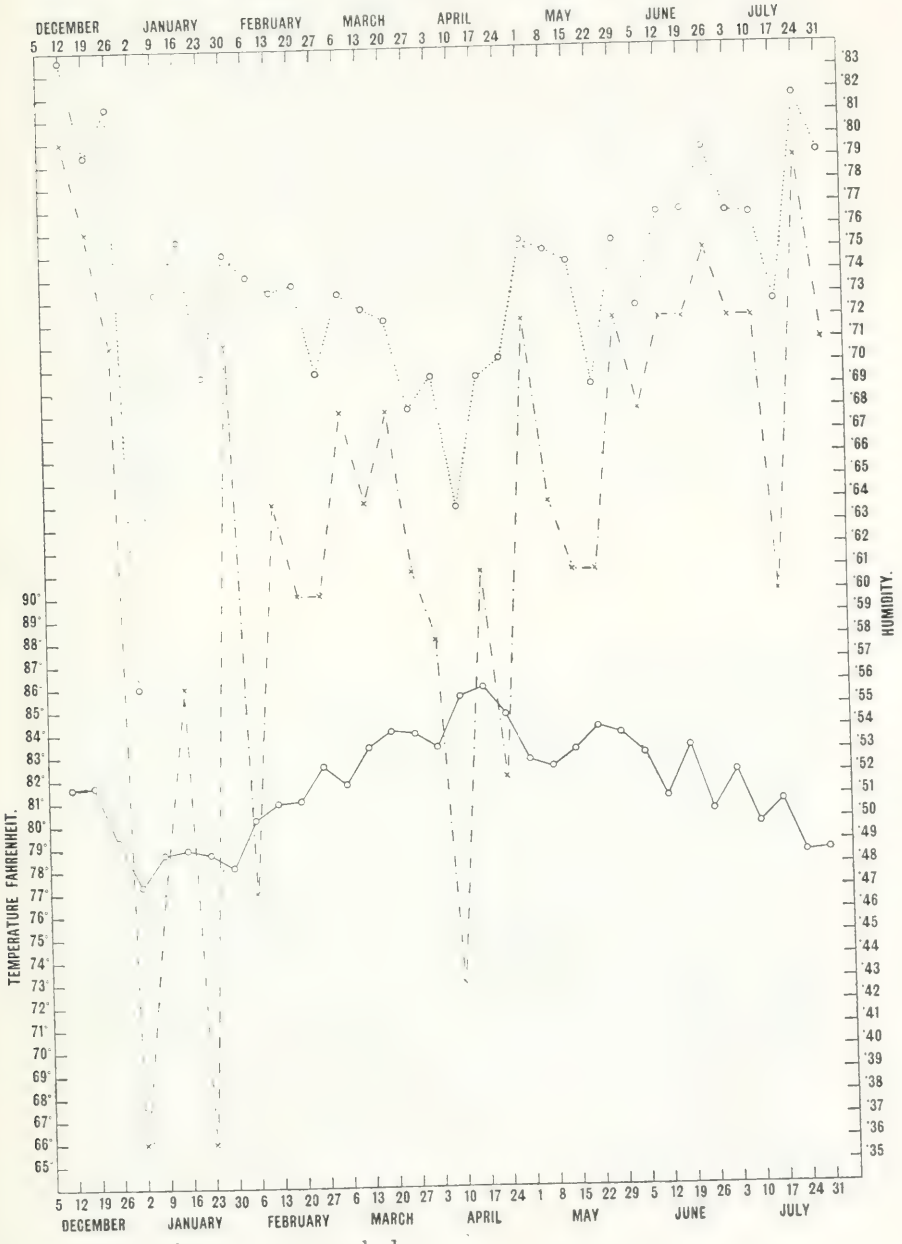
Curves of Temperature and Humidity in Compound at Colonial Hospital, Freetown.



Observations at 9 a.m. each day :—
Temperature ———— Humidity . . . . . .
Minimum Humidity record in each week — . — . — . — .

Chart No. 5.

Curves of Temperature and Humidity in Animal House at Colonial Hospital, Freetown.



Observations at 9 a.m. each day :—

Temperature ———— Humidity . . . . . .

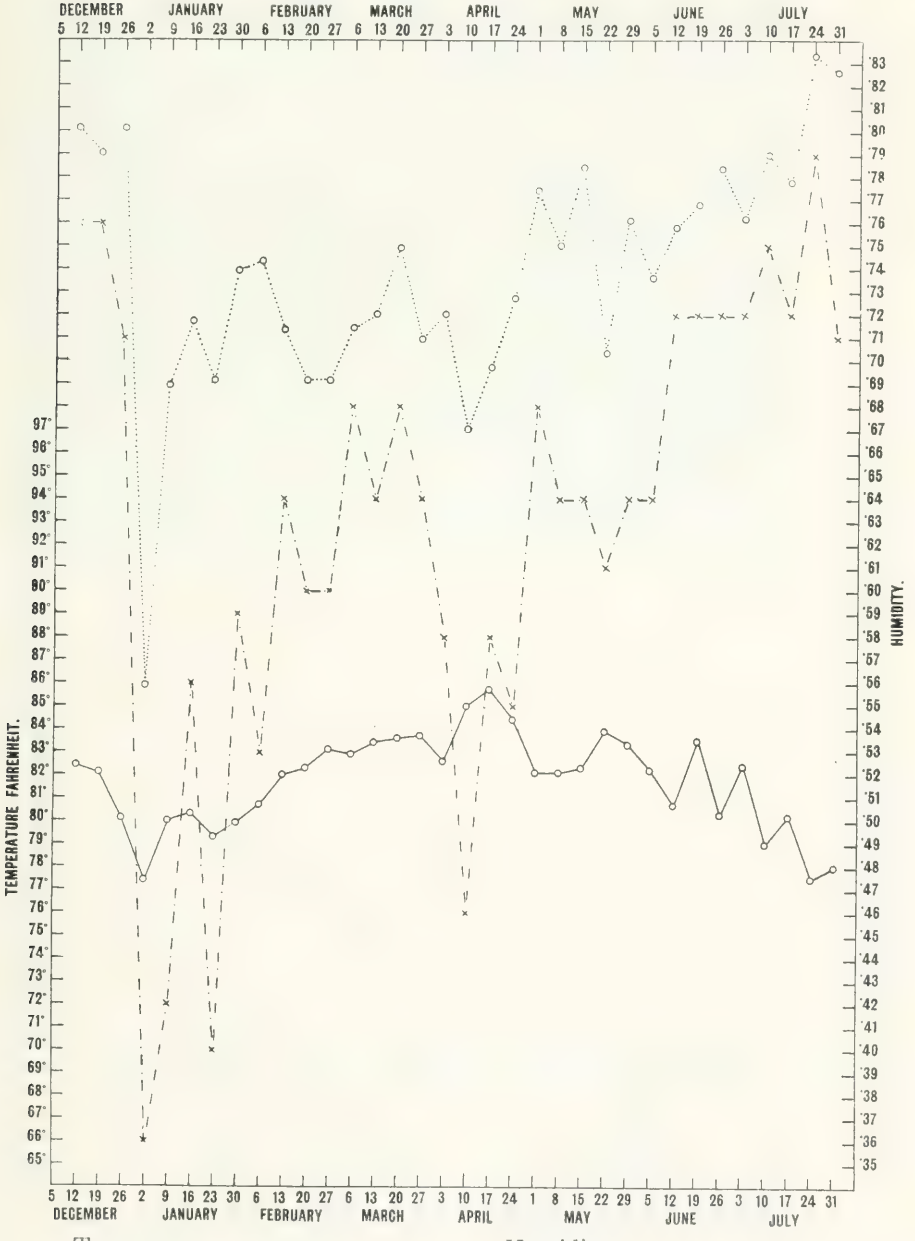
Minimum Humidity record in each week — · — · — · — · —

Plate No. 20.
Animal House, Colonial Hospital, Freetown.

Plate No. 21.
The Mosquito House.

Chart No. 6.

Curves of Temperature and Humidity in Mosquito House at Colonial Hospital, Freetown.

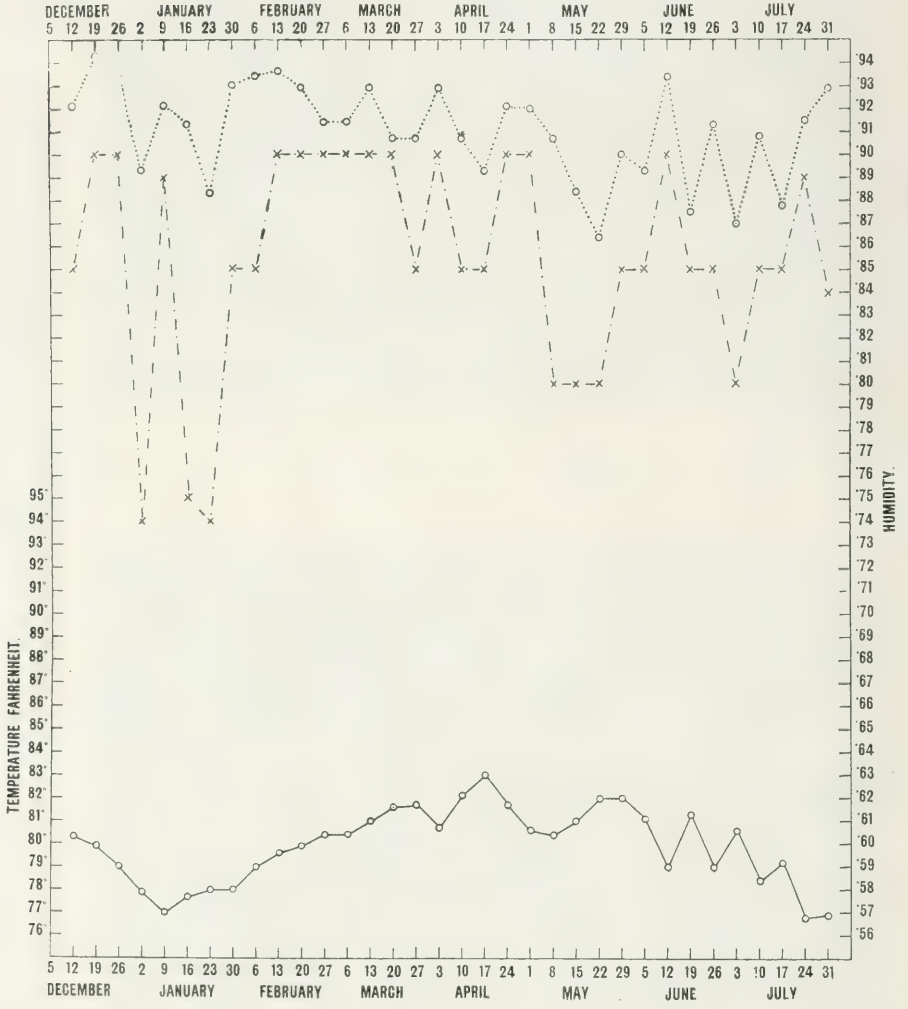


Temperature———————— Humidity . . . . . .

Minimum Humidity record in each week-- · · · — · — ·

Chart No. 7.

Curves of Temperature and Humidity in the Mosquito House Pit.



Observations at 9 a.m. each day :—

Temperature ———————— Humidity . . . . . .

Minimum Humidity record in each week— · — · — · — ·

Well. (Plate No. 22). This was covered, but owing to the larger air space it was better ventilated and less humid than the pit in the mosquito house.

Plate No. 22.

Well in Sanitary Department Compound, showing method of suspending tubes containing adults under a tin of water to isolate from ants.

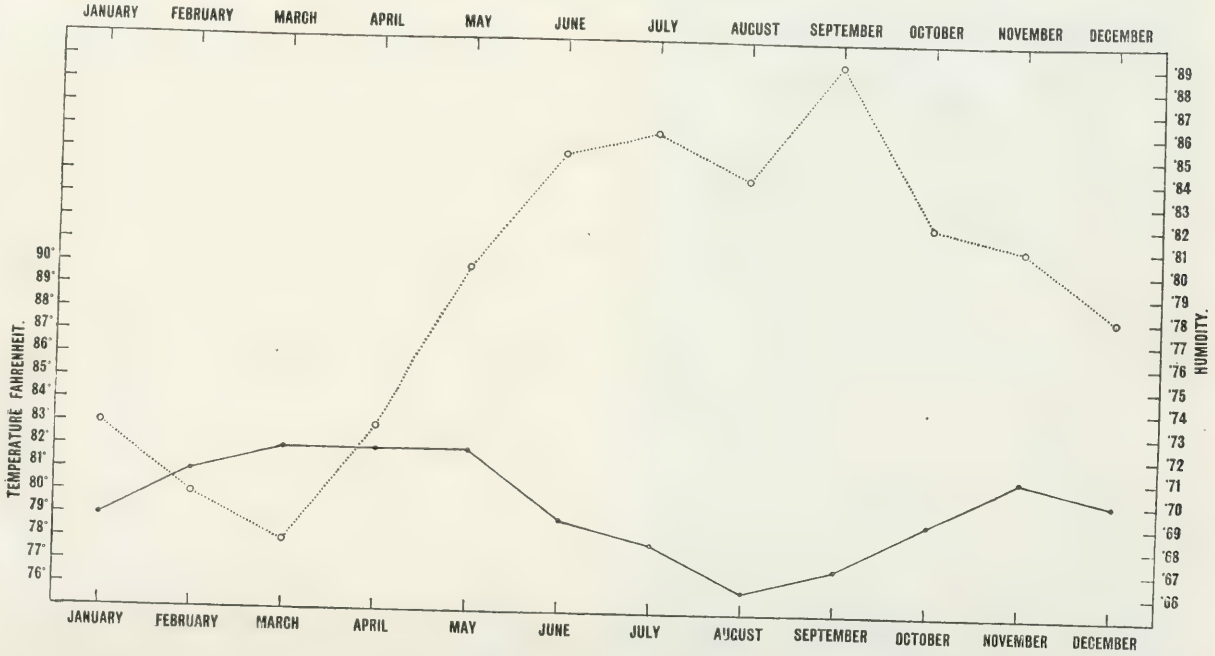
Temperature and Humidity Records at 3 feet above Water Level in the Well in the compound of the Sanitary Department, Water Street, Freetown.

Date.	Temperature.	Humidity.	Date.	Temperature.	Humidity.
21 December...	82° F.	...	3 March ...	83° F.	·85
23 ,, ...	82 ,,	·80	5 ,, .	82° ,,	·90
26 ,, ...	81 ,,	·90	9 ,, ...	82 ,,	·90
			13 ,, ...	83 ,,	·80
			16 ,, ...	85 ,,	·76
18 January ...	81 ,,	·85	19 ,, ...	82 ,,	·90
21 ,, ...	82 ,,	·90			
25 ,, ...	80 ,,	·90	2 April ...	85 ,,	·72
28 ,, ...	80 ,,	·90	6 ,, ...	84 ,,	·80
			9 ,, ...	84 ,,	·80
			13 ,, ...	85 ,,	·76
1 February ...	80 ,,	·95	16 ,, ...	83 ,,	·90
4 ,, ...	80 ,,	·95	20 ,, ...	84 ,,	·80
8 ,, ...	81 ,,	·90	23 ,, ...	82 ,,	·90
26 ,, ...	82 ,,	·85	27 ,, ...	83 ,,	·85

Observations made at 10 a.m.

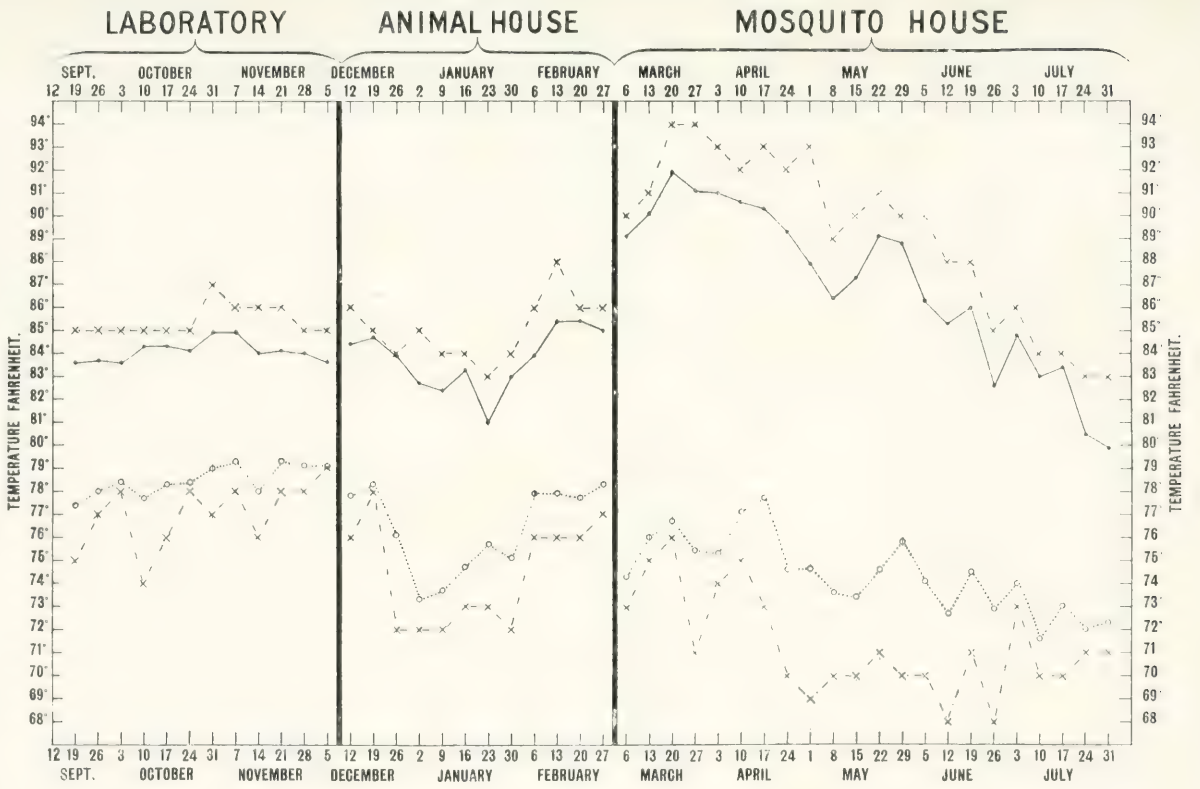
Chart No. 8.

Curves of Temperature and Humidity at the Meteorological Station, Freetown, Sierra Leone (224 feet above sea level).



Observations at 9 a.m. Monthly means compiled from the Official Report for 1914.

Curves of Maximum and Minimum Temperatures and Weekly Extremes.



In the Laboratory from September 11th to December 4th; in the Animal House from December 4th to February 27th and in the Mosquito House from February 27th to July 31st.

Maximum Temperature———— Minimum Temperature . . . . . .

Extremes for each week . . . . .

The following tests were carried out in the above-mentioned situations, and the results were as follows :—

YARD AT 26, WESTMORELAND STREET.

Unfed.

141 emerged 23rd to 25th January. Period of experiment, 25th to 28th January. 71 males, 70 females.

85	lived	1 day	Average 1·4 days.
49	,,	2 days	
7	,,	3 ,,	
141			

Fed Honey.

91 emerged 16th to 18th December. Period of experiment, 18th to 28th December. 34 males, 57 females.

4	lived	5 days	All or nearly all males. Average 8·3 days.
4	,,	6 ,,	
41	,,	8 ,,	
33	,,	9 ,,	
9	,,	10 ,,	
91			

Fed Thin Syrup.

About 100 emerged 27th February to 1st March. Period of experiment, 1st to 15th March.

5	lived	1 day	Average 9·3 days.
4	,,	4 days	
3	,,	6 ,,	
5	,,	8 ,,	
24	,,	10 ,,	
6	,,	12 ,,	
9	,,	13 ,,	
56	*unfinished.*		

Ants got into the tube and carried off all that remained. To accomplish this they must have crossed a two-inch water surface or have dropped three inches from the roof of the pen on to the tube.

A Second Attempt.—114 emerged 2nd to 4th April. Period of experiment, 4th to 28th April.

5	lived	1	day	
2	,,	2	days	
6	,,	3	,,	
2	,,	4	,,	
5	,,	6	,,	
16	,,	7	,,	
39	,,	8	,,	} Average 8·6 days.
15	,,	10	,,	
1	,,	11	,,	
13	,,	12	,,	
4	,,	15	,,	
4	,,	16	,,	
2	,,	24	,,	
114				

*Fed on Blood.**

15 minutes' opportunity for feeding given daily. 103 emerged 28th to 30th December. Period of experiment, 30th December to 7th February. 51 males, 52 females.

8	lived	1	day	
6	,,	3	days	
4	,,	4	,,	
6	,,	5	,,	
14	,,	6	,,	
11	,,	7	,,	
7	,,	9	,,	
1	,,	10	,,	
6	,,	11	,,	
4	,,	14	,,	} Average 10·8 days.
16	,,	16	,,	
8	,,	17	,,	
2	,,	18	,,	
1	,,	19	,,	
1	,,	22	,,	
4	,,	23	,,	
2	,,	24	,,	
1	,,	35	,,	
1	,,	39	,,	
103				

* In tests when the mosquitoes are fed on blood, allowance must be made for the average being reduced by the early death of the males.

In Cage in Room at 26, Westmoreland Street.

Fed Honey.

42 emerged 25th to 26th November. Period of experiment, 26th November to 30th December. 16 males, 26 females.

16	lived	9	days	
4	,,	10	,,	
9	,,	13	,,	
10	,,	15	,,	Average 12·3 days.
1	,,	21	,,	
1	,,	22	,,	
1	,,	24	,,	
42				

Fed Honey.

75 emerged 22nd to 24th December. Period of experiment, 24th to 30th December. 9 males, 66 females.

3	lived	3	days	
32	,,	4	,,	Average 4·6 days.
32	,,	5	,,	
8	,,	6	,,	
75				

Hospital Compound. (Slight Shade.)

Unfed.

124 emerged 19th to 21st January. Period of experiment, 21st to 24th January. 39 males, 85 females.

9	lived	1	day	
103	,,	2	days	Average 2 days.
12	,,	3	,,	
124				

Fed Honey.

173 emerged 18th to 20th December. Period of experiment 20th to 26th December. 99 males, 74 females.

8	lived	2	days	
7	,,	3	,,	
51	,,	4	,,	Average 5·2 days.
87	,,	5	,,	
20	,,	6	,,	
173				

Fed on Blood.

15 minutes' opportunity given each day. 106 emerged 28th to 30th December. Period of experiment, 30th December to 18th January. 56 males, 50 females.

8	lived	3	days	23 of these were males.
22	,,	4	,,	
8	,,	5	,,	
17	,,	6	,,	
5	,,	7	,,	Average 7·2 days.
18	,,	8	,,	
20	,,	11	,,	Feeding was omitted on 11th day.
6	,,	13	,,	
1	,,	16	,,	
1	,,	19	,,	
106				

Mosquito House Pit.

Unfed.

About 100 emerged 17th to 19th January. Period of experiment, 19th to 31st January. Examination for sex omitted.

2	lived	4	days	
34	,,	5	,,	
21	,,	7	,,	Average 6·8 days.
37	,,	8	,,	
3	,,	10	,,	
3	,,	12	,,	
100				

Fed Honey.

About 100 emerged 7th to 9th January. Period of experiment, 9th January to 6th February. Sexes unrecognisable.

2	lived	8	days	
21	,,	15	,,	
27	,,	17	,,	
9	,,	18	,,	Average 18·1 days.
34	,,	20	,,	
3	,,	24	,,	
2	,,	26	,,	
2	,,	28	,,	
100				

Mosquito House—Suspended 2 inches Clear of Soil.

Fed Honey.

48 emerged 5th to 6th December. Period of experiment, 6th to 20th December. 22 males, 26 females.

3	lived	7	days
14	,,	8	,,
10	,,	9	,,
16	,,	10	,,
2	,,	11	,,
2	,,	12	,,
1	,,	14	,,
48			

Average 9·2 days.

Mosquito House—On Ground and Covered with Fallen Leaves.

Fed Honey.

100 emerged 18–20th December. Period of experiment, 20th December to 20th January. Within four days the ants had killed and carried away all but seven or eight. These were gradually killed off. Two managed to escape until the 9th of January.

Longest life, 20 days.

Mosquito House—Suspended 5 Feet from the Ground.

Fed Honey.

60 emerged 11th to 12th December. Period of experiment, 12th to 22nd December. 30 males, 30 females.

3	lived	1	day
27	,,	2	days
27	,,	3	,,
1	,,	4	,,
2	,,	10	,,
60			

Average 2·7 days.

Mosquito House Pit.

*Fed on Blood.**

At weekly intervals, no other food. About 100 emerged, 17th to 19th January. Period of experiment, 19th January to 8th February.

2	lived	4	days	
23	,,	5	,,	
16	,,	7	,,	
38	,,	8	,,	
14	,,	10	,,	Average 7·9 days.
2	,,	12	,,	
1	,,	14	,,	
1	,,	16	,,	
1	,,	18	,,	
2	,,	20	,,	
100				

Well in Sanitary Department Compound (about 20 to 25 feet to water level).

Lined masonry, about 6 or 8 feet, through surface soil, unlined through the solid laterite rock, diameter 5 to 6 feet. Tubes let down to within 3 feet of water.

Fed Honey.

About 100 emerged, 17th to 18th December. Period of experiment, 18th to 26th December.

There were never any dead, but tell-tale remnants of legs and wings showed that the ants were at work. All the specimens were killed and carried off within eight days.

Another attempt was made, an antiformica of suitable design being used. About 100 emerged 13th to 14th January. Period of experiment, 14th January to 11th February.

6	lived	10	days	
8	,,	13	,,	
46	,,	17	,,	Average at least 17·8 days.
11	,,	20	,,	
20	,,	24	,,	
91				

The experiment was unfinished, as the cord rotted through, and the antiformica tube and contents were lost.

* Allowance must be made for the early death of the males which were present but in undetermined numbers.

Fed Thin Syrup.

About 100 emerged 24th to 26th February. Period of experiment, 26th February to 23rd March.

14	lived	7	days	
19	,,	11	,,	
16	,,	14	,,	Average 14·3 days.
43	,,	18	,,	
2	,,	21	,,	
94				

The experiment was unfinished, as the rope rotted through, and the antiformica and tubes with it were lost.

A later attempt was made, copper wire being used in place of rope.

About 100 emerged 31st March to 2nd April. Period of experiment, 2nd to 27th April.

5	lived	4	days	
18	,,	7	,,	
47	,,	11	,,	
18	,,	14	,,	Average 11·3 days.
8	,,	16	,,	
2	,,	21	,,	
2	,,	25	,,	
100				

Given One Meal of Blood, then Fed on Syrup.

About 100 emerged 24th to 26th February. Period of experiment, 26th February to 19th March.

10	lived	7	days	
39	,,	11	,,	
3	,,	14	,,	Average 13·4 days.
30	,,	18	,,	
2	,,	21	,,	
84				

Experiment was unfinished, as the rope rotted through.

Another attempt was made, wire replacing the rope.

About 100 emerged 31st March to 2nd April. Period of experiment, 2nd to 23rd April.

4	lived	4	days	
18	,,	7	,,	
38	,,	11	,,	Average 11·8 days.
25	,,	14	,,	
14	,,	18	,,	
1	,,	21	,,	
100				

ANIMAL HOUSE—SUSPENDED ABOUT 2 FEET ABOVE FLOOR

Fed Honey.

51 emerged 9th to 10th December. Period of experiment, 10th to 18th December.

4	lived	3	days	)
8	,,	4	,,	Average 5·7 days.
31	,,	6	,,	
8	,,	8	,,	)
51				

Experiment No. XXXV.

LENGTH OF LIFE OF MALES AND FEMALES WHEN FED ON BANANAS ONLY.

A little water was added if the banana was not juicy. Kept in a H.L.C.* cage over *wet* filter paper. Emerged 17th to 19th March.

Date of death.	Males.	Females.	Number of days after emergence.	Remarks.
20 March	1 dead	Nil	1	
21 ,,	6 ,,	1 dead	2	
22 ,,	Nil	1 ,,	3	
23 ,,	1 dead	2 ,,	4	
26 ,,	1 ,,	2 ,,	7	
28 ,,	Nil	3 ,,	9	
29 ,,	1 dead	1 ,,	10	
30 ,,	3 ,,	Nil	11	
31 ,,	6 ,,	2 dead	12	
1 April	4 ,,	...	13	
2 ,,	2 ,,	3 dead	14	
4 ,,	3 ,,	2 ,,	16	
6 ,,	1 ,,	3 ,,	18	
7 ,,	Nil	1 ,,	19	
8 ,,	1 dead	Nil	20	
9 ,,	1 ,,	2 dead	21	
10 ,,	1 ,,	2 ,,	22	
11 ,,	1 ,,	6 ,,	23	
13 ,,	Nil	2 ,,	25	
14 ,,	,,	2 ,,	26	
18 ,,	,,	1 ,,	30	
21 ,,	,,	1 ,,	33	
24 ,,	,,	1 ,,	36	
26 ,,	,,	1 ,,	38	
27 ,,	,,	1 ,,	39	
30 ,,	,,	1 ,,	42	
4 May	,,	1 ,,	46	
	33	42		

Average life: males 10·9 days; females 19·6 days.
Longest ,, ,, 23 ,, ,, 46 ,,

* Cage made out of a hurricane lamp chimney. See illustration, page 175.

Experiment No. XXXVII.

LENGTH OF LIFE OF MALES AND FEMALES FED ON SYRUP ONLY.

Kept in a H.L.C. cage over *wet* filter paper. Emerged 17th to 19th February.

Date of death.	Males.	Females.	Number of days after emergence.	Remarks.
20 February	1 dead	Nil	1	
28 ,,	2 ,,	1 dead	9	
1 March	5 ,,	2 ,,	10	Under these moist conditions the insects are prone to get their legs smeared with syrup, and this causes a certain amount of mortality.
2 ,,	1 ,,	1 ,,	11	
3 ,,	1 ,,	Nil	12	
4 ,,	1 ,,	,,	13	
6 ,,	2 ,,	,,	15	
7 ,,	2 ,,	,,	16	
8 ,,	1 ,,	1 dead	17	
11 ,,	1 ,,	4 ,,	20	
12 ,,	3 ,,	1 ,,	21	
14 ,,	2 ,,	Nil	23	
15 ,,	4 ,,	3 dead	24	
16 ,,	Nil	15 ,,	25	*A tiny leak in the syrup pan led to a high concentration, which may have been partly responsible for this sudden increase in the death rate.
17 ,,	1 dead	7 ,,	26	
18 ,,	Nil	1 ,,	27	
19 ,,	1 dead	3 ,,	28	
20 ,,	Nil	2 ,,	29	
21 ,,	,,	1 ,,	30	
23 ,,	,,	2 ,,	32	
31 ,,	,,	1 ,,	40	
5 April	,,	1 ,,	45	
7 ,,	,,	1 ,,	47	
9 ,,	,,	1 ,,	49	
10 ,,	1 dead	Nil	50	
21 ,,	Nil	1 dead	60	
	29	49		

Average life : males, 17·6 days ; females, 26·3 days.
Longest ,, : ,, 50 ,, : ,, 60 ,,

Experiment No. XXXVIII.

LENGTH OF LIFE OF MALES AND FEMALES FED ON SYRUP ONLY (BOILED WATER AND TATE CUBE SUGAR).

Kept in a H.L.C. cage over *dry* filter paper. Emerged 10th to 12th February.

Date of death.	Males.	Females.	Number of days after emergence.	Remarks.
13 February	Nil	1 dead	1	
18 ,,	1 dead	Nil	6	
24 ,,	1 ,,	,,	12	
6 March	1 ,,	,,	22	
7 ,,	1 ,,	,,	23	
8 ,,	1 ,,	1 dead	24	
11 ,,	4 ,,	Nil	27	
12 ,,	Nil	1 dead	28	
13 ,,	1 dead	Nil	29	
15 ,,	Nil	1 dead	31	
16 ,,	2 dead	Nil	32	
17 ,,	1 ,,	,,	33	
18 ,,	Nil	1 dead	34	
19 ,,	3 dead	2 ,,	35	
20 ,,	1 ,,	3 ,,	36	
22 ,,	1 ,,	1 ,,	38	
23 ,,	Nil	2 ,,	39	
24 ,,	,,	2 ,,	40	
25 ,,	1 dead	Nil	41	
26 ,,	1 ,,	1 dead	42	
27 ,,	Nil	1 ,,	43	
28 ,,	,,	1 ,,	44	
31 ,,	,,	4 ,,	47	
1 April	,,	2 ,,	48	
2 ,,	,,	2 ,,	49	
4 ,,	,,	2 ,,	51	
7 ,,	,,	1 ,,	54	
9 ,,	,,	1 ,,	56	
11 ,,	,,	1 ,,	58	
12 ,,	,,	1 ,,	59	
14 ,,	,,	1 ,,	61	
16 ,,	,,	1 ,,	63	
21 ,,	,,	1 ,,	68	
	20	35		

Average life : males, 29 days ; females, 44·1 days.
Longest ,, : ,, 42 ,, ; ,, 68 ,,

Experiment No. XXXIX.

RELATIVE LENGTH OF LIFE OF MALES AND FEMALES FED ON HONEY ONLY.

Kept in a H.L.C. cage over *wet* filter paper. Emerged 24th to 25th November.

Date of death.	Males.	Females.	Number of days after emergence.	Remarks.
7 December	1 dead	Nil	12	
14 ,,	2 ,,	,,	19	
18 ,,	1 ,,	2 dead	23	
19 ,,	Nil	2 ,,	24	
20 ,,	,,	1 ,,	25	
21 ,,	,,	2 ,,	26	
22 ,,	,,	3 ,,	27	
24 ,,	2 dead	1 ,,	29	
25 ,,	Nil	1 ,,	30	
27 ,,	,,	2 ,,	32	
28 ,,	,,	1 ,,	33	
29 ,,	,,	2 ,,	34	
30 ,,	,,	1 ,,	35	
31 ,,	,,	1 ,,	36	
4 January	,,	1 ,,	40	
6 ,,	,,	1 ,,	42	
12 ,,	,,	1 ,,	48	
15 ,,	,,	1 ,,	51	
17 ,,	,,	1 ,,	53	
	6	24		

Average life: males 21·8 days; females 32·5 days.
Longest ,, : ,, 29 ,, : ,, 53 ,,

Experiment No. XL.

RELATIVE LENGTH OF LIFE OF MALES AND FEMALES FED ON HONEY ONLY.

Kept in a H.L.C. cage, over *dry* filter paper. Emerged 3rd to 5th January.

Date of Death.	Males.	Females.	Number of days after emergence.	Remarks.
6 January	1 dead	Nil	1	
7 „	2 „	„	2	
8 „	Nil	1 dead	3	
9 „	10 dead	9 „	4	
10 „	1 „	4 „	5	
16 „	1 „	Nil	11	
18 „	1 „	1 dead	13	
19 „	Nil	1 „	14	
20 „	4 dead	3 „	15	
21 „	2 „	1 „	16	
22 „	2 „	1 „	17	
23 „	5 „	6 „	18	
24 „	Nil	3 „	19	
29 „	„	1 „	24	
	29	31		

Average life: males 10 days; females 11·4 days.
Longest „ : „ 18 „ : „ 24 „

Experiment No. XLI.

EGG PRODUCTION AFTER A SINGLE MEAL OF BLOOD, AND EVIDENCE OF THE EGG RETAINING HABIT, AND ALSO SHOWS COMPARATIVE LENGTH OF LIFE OF MALES AND FEMALES.

A number of males and females which emerged on the 1st to 3rd December were allowed free intercourse in a large cage. The females were given an opportunity of feeding on human blood; those that filled themselves to repletion were selected for the experiment. Twelve males and 23 females were transferred to a H.T.C. cage with *wet* filter paper at base, and supplied liberally with honey.

Date of deposition of eggs or death.	Number of eggs laid.	Fertility.	Death of males.	Death of females.	Number of days after meal of blood.	Remarks.
4 December	61	+	...	...	2	The number of eggs laid presupposes that only two or at the most three females were laying.
5 ,,	51	+	...	...	3	
6 ,,	5	+	...	...	4	
7 ,,	148	+	...	...	5	
8 ,,	4	+	...	...	6	
9 ,,	11	+	...	...	7	
10 ,,	...		1 dead	...	8	
12 ,,	5	+	...	2 dead	10	
13 ,,	4	+	...	1 ,,	11	
14 ,,	1	+	...	1 ,,	12	
15 ,,	13	+	1 dead	...	13	
17 ,,	...	...	4 ,,	...	15	
20 ,,	...	...	1 ,,	...	18	
21 ,,	41	+	1 ,,	...	19	
22 ,,	1	+	...	1 dead	20	
25 ,,	4	+	...	...	23	
26 ,,	31	+	1 escaped	2 dead	24	
27 ,,	11	+	...	3 ,,	25	
28 ,,	1	+	2 dead	...	26	
29 ,,	1	+	...	1 dead	27	
30 ,,	32	+	...	...	28	
31 ,,	4	+	...	...	29	
1 January	19	+	...	1 dead	30	
2 ,,	...	...	...	1 ,,	31	
5 ,,	170	+	...	...	34	
6 ,,	13	+	...	1 dead	35	
7 ,,	...	...	...	1 ,,	36	
8 ,,	...	...	1 dead	...	37	
9 ,,	...	...	...	2 dead	38	
11 ,,	105	+	...	1 ,,	40	
16 ,,	3	−	...	...	45	
20 ,,	...	...	...	1 dead	49	
25 ,,	...	...	...	3 ,,	54	
13 February	...	...	...	*1 ,,	73	

* The ovaries of this female on dissection proved to be fully developed and the eggs ripe for laying, many of them being already brown. It is significant that this should be the case 70 days after the only meal of blood she received.

Average life : 12 males 18·8 days ; 23 females 32·3 days.
Longest ,, : ,, ,, 37 ,, : ,, ,, 73 ,,

Experiment No. XLII.

EVIDENCE OF EGG RETAINING HABIT AND LENGTH OF LIFE AFTER A SINGLE MEAL OF BLOOD (SUBSEQUENT FOOD HONEY).

Females which emerged on the 5th, 6th, 7th, 8th and 9th December were kept for 24 hours in a cage with a number of males, they were then allowed one full meal of blood (Nos. 1, 2, 3, 4 and 5 on the 7th December, Nos. 6, 7 and 8 on the 9th December, Nos. 9, 10 and 11 on the 10th December). Each female was then placed in a separate jar with *wet* filter paper at the bottom and fed on honey.

Date of deposition of eggs or death.	Identification number.	Number of eggs laid.	Fertility.	Death.	Number of days after meal of blood.	Remarks.
8 December	2	...	...	died	1	
10 ,,	4	69	+	...	3	
,,	5	46	+	...	3	
11 ,,	4	1	...	...	4	No record of hatching.
,,	5	1	..	...	4	,, ,, ,, ,,
,,	6	71	+	...	2	
,,	8	13	+	...	2	
12 ,,	5	1	...	...	5	No record of hatching.
,,	6	1	...	...	5	,, ,, ,, ,,
,,	8	52	+	...	3	
,,	9	1	...	...	3	No record of hatching.
,,	10	60	+	...	2	
,,	11	38	+	...	2	
13 ,,	4	4	+	...	6	
,,	6	1	...	...	4	No record of hatching.
15 ,,	11	2	...	...	5	,, ,, ,, ,,
16 ,,	3	...	...	escaped	9	Laid no eggs.
17 ,,	6	1	...	...	8	
,,	9	1	+	...	7	
,,	11	2	+	...	7	
18 ,,	7	...	...	died	9	Laid no eggs.
19 ,,	4	2	...	...	12	
20 ,,	5	...	...	died	13	
,,	9	2	+	...	10	
,,	11	2	+	...	10	
26 ,,	6	...	...	died	17	
31 ,,	10	...	...	,,	21	
1 January	11	...	...	,,	22	
2 ,,	9	1	+	...	23	
6 ,,	8	1	-	...	28	Egg infertile.
,,	9	2	+	...	28*	*These eggs resisted immersion. After three months' dry storage one of them retained its shape but did not hatch in spite of a long period in water. On the 26th April it was opened and found to contain a living larva.
10 ,,	8	...	...	died	32	
13 ,,	1	...	...	,,	37	
24 ,,	9	1	infertile	...	46	
26 ,,	4	...	...	died	50	
1 February	9	...	...	,,	53	

Average life : 25·6 days ; longest life : 53 days.

Experiment No. XLIII.

TEST TO ASCERTAIN IF WELL-FED FEMALES WOULD OVIPOSIT APART FROM WET SURFACES, AND THEIR LENGTH OF LIFE WHEN EGGS HAVE TO BE RETAINED OWING TO DROUGHT.

Females that emerged between the 20th and 29th December were allowed free intercourse with a number of males in a large cage.

Those which fed readily on a human arm were selected and placed in a H.T.C. cage based on *dry* filter paper, the top covered with fine gauze; no additional cover being used to prevent evaporation.

A supply of honey was kept in the cage, and a ten minutes' opportunity of taking human blood was afforded each night.

Date of deposition of eggs or death.	Number of eggs laid.	Fertility.	Death.	Number of days after first meal of blood.	Remarks.
31 December	1	infertile	1	2	
2 January	...	...	1	4	
7 ,,	...	...	1	9	
8 ,,	...	...	3	10	
9 ,,	...	...	3	11	
22 ,,	...	...	1	24	
23 ,,	...	...	6	25	
24 ,,	...	...	1	26	
25 ,,	...	...	1	27	
29 ,,	...	...	1	31	
30 ,,	...	...	1	32	
31 ,,	...	...	1	33	
1 February	...	...	2	34	
2 ,,	...	...	1	35	
3 ,,	...	...	2	36	
4 ,,	...	...	1	37	
5 ,,	...	...	2	38	
7 ,,	...	...	3	40	
8 ,,	...	...	2	41	
11 ,,	...	...	1	44*	*This female when dying was placed in a small tube with a piece of *wet* filter paper. She immediately commenced to oviposit and laid a small batch of *infertile* eggs.
5 March	...	...	1	66	
12 ,,	...	...	1	73	
13 ,,	...	...	2	74	
			39		

Average life, 31·3 days; longest life, 74 days.

Only one infertile egg was laid on dry paper, although a dying female laid at once when provided with a wet surface.

Conclusion: *Water or wet surfaces* are essential to egg laying.

Experiments Nos. XLI. and XLII. It will be noted that female No. 1 lived 37 days but died without ovipositing, while Nos. 3 and 7 also failed to lay any eggs. Unfortunately, time did not permit of the dissection of Nos. 1 and 7 to ascertain if their ovaries were ripe, or if they were awaiting further meals of blood before developing them. It seems more probable, however, that the eggs were being retained.

The oviposition of females Nos. 4, 5, 6, 8, 10, and 11 was not very unusual, but that of No. 9 was distinctly abnormal, in that she dribbled out pairs or single eggs at long intervals. Those laid 23 and 28 days after the initial meal of blood proved to be fertile. Time did not permit of her dissection.

If the two experiments are considered together there seems to be a strong case made out for the instinctive retention of eggs by a proportion of the females, and this is probably the explanation why certain females in earlier experiments failed to lay, although they were afforded opportunities of sucking human blood every night.

TWO EXPERIMENTS TO ILLUSTRATE EGG PRODUCTION AND LAYING, APART FROM FEEDING ON A LIVING ANIMAL.

Attempts were made to induce egg production by feeding on mixtures of honey and white of egg, honey and dried blood, honey and fresh blood, syrup and fresh blood.

Honey and white of egg kept well in a stoppered jar for three weeks, but fermented within a day or two when placed in the cage for the females to feed on. Honey and dried blood did not keep well, possibly owing to water being used to mix the blood into a paste before adding it to the honey.

Honey and fresh blood and syrup and fresh blood kept for months when placed in a desiccator to cause a high concentration of sugar.

The first attempts with honey and white of egg, honey and dried blood, and honey and fresh blood were all negative. Some 50 to 100 females were used in each case, equal or larger numbers of males being kept with them. Pairing took place freely but the ovaries never developed, although the average life was considerable. The sole surviving female in one of the experiments, after living for 56 days, was given the opportunity of sucking human blood. She fed sparingly on three successive nights, then missed a night, and laid 21 fertile eggs on the following night. After depositing the eggs she bit but did not obtain blood, and died the next day. Two attempts, Experiments Nos. XXIV. and XXV., were then made, in one, honey

and fresh blood from a sheep was again used, in the other, syrup and fresh blood from a sheep. As will be seen from the following records both met with sufficient success to be of interest theoretically, but so modified as to afford little hope of the method proving of any practical assistance in future research.

Experiment No. XLIV.

A number of males and females, which emerged on the 13th and 14th January, were placed in a hurricane lamp chimney cage on *wet* filter paper, and given an ample supply of honey mixed with blood from a sheep. This was changed on the first signs of fermentation.

Date of deposition of eggs or deaths.	Number of eggs laid.	Fertility.	Death of males.	Death of females.	Number of days after start.	Remarks.
17 January	...	...	4 dead	2 dead	3	
18 ,,	...	...	3 ,,	Nil	4	
19 ,,	...	...	Nil	1 dead	5	
20 ,,	...	...	3 dead	1 ,,	6	
22 ,,	...	...	2 ,,	Nil	8	
23 ,,	...	...	1 ,,	,,	9	
24 ,,	...	...	2 ,,	,,	10	
25 ,,	...	...	2 ,,	,,	11	
27 ,,	...	...	4 ,,	,,	13	
28 ,,	...	...	1 ,,	,,	14	
30 ,,	...	...	4 ,,	5 dead	16	
31 ,,	...	...	3 ,,	Nil	17	
1 February	...	...	7 ,,	,,	18	
2 ,,	...	...	1 ,,	,,	19	
3 ,,	...	...	6* ,,	4*dead	20	*Most of these died from mechanical causes, their legs getting fixed in the sticky mixture owing to rapid drying.
4 ,,	...	...	Nil	2 ,,	21	
5 ,,	...	...	1 dead	2 ,,	22	
6 ,,	...	...	1 ,,	3 ,,	23	
7 ,,	...	...	1 ,,	3 ,,	24	
8 ,,	...	...	1 ,,	1 ,,	25	
9 ,,	...	...	Nil	1 ,,	26	
10 ,,	...	...	,,	2 ,,	27	
11 ,,	...	...	,,	2 ,,	28	
12 ,,	...	...	,,	1 ,,	29	
13 ,,	...	...	1 dead	1 ,,	30	
16 ,,	...	...	Nil	1 ,,	33	
17 ,,	...	...	1 dead	1 ,,	34	
19 ,,	...	...	Nil	2 ,,	36	
24 ,,	...	...	,,	1 ,,	41	
25 ,,	...	...	,,	1 ,,	42	
27 ,,	...	...	,,	2 ,,	44	
28 ,,	...	...	,,	1 ,,	45	
1 March	...	...	,,	1 ,,	46	
2 ,,	1	*Infertile*	,,	Nil	47	
7 ,,	...	...	,,	1 dead	52	
12 ,,	...	...	,,	1 ,,	57	
12 April	...	...	,,	1 ,,	88	
			49	44		

Result.—1 infertile egg.

Average life : males, 14·6 days ; females, 27·8 days.

Longest ,, : ,, 34 ,, ; ,, 88 ,,

Experiment No. XLV.

A number of males and females which emerged on the 1st and 2nd March were placed in a H.L.C. cage over *wet* filter paper and given an ample supply of syrup mixed with blood from a sheep. The supply was changed on the first sign of fermentation.

Date of deposition of eggs or death.	Number of eggs laid.	Fertility.	Death of males.	Death of females.	No. of days from start.	Remarks.
4 March	1	+	...	2 dead	2	The egg hatched on 7th March.
5 ,,	...	...	1 dead	Nil	3	
6 ,,	...	...	0 .	,,	4	
7 ,,	...	...	1 ,,	,,	5	
8 ,,	...	...	2 ,,	,,	6	
9 ,,	...	...	3 ,,	,,	7	
11 ,,	...	..	2 ,,	2 dead	9	
12 ,,	...	...	Nil	2 ,,	10	
14 ,,	...	...	1 dead	1 ,,	12	
15 ,,	...	...	2 ,,	Nil	13	
16 ,,	...	...	1 ,,	1 dead	14	
17 ,,	...	...	1 ,,	3 ,,	15	
20 ,,	...	...	Nil	1 ,,	18	
22 ,,	..	...	2 dead	3 ,,	20	
23 ,,	...	...	1 ,,	1 ,,	21	
24 ,,	...	...	1 ,,	Nil	22	
25 ,,	...	...	Nil	2 dead	23	
26 ,,	...	...	1 dead	2 ,,	24	
27 ,,	...	...	1 ,,	4 ,,	25	
28 ,,	...	...	1 ,,	1 ,,	26	
29 ,,	...	...	1 ,,	3 ,,	27	
30 ,,	..	...	1 ,,	2 ,,	28	
1 April	...	...	2 ,,	5 ,,	30	
2 ,,	...	...	3 ,,	1 ,,	31	
3 ,,	...	...	1 ,,	1 ,,	32	
5 ,,	...	...	Nil	1 ,,	34	
6 ,,	...	...	,,	2 ,,	35	
8 ,,	...	...	,,	1 ,,	37	
19 ,,	...	...	,,	2 ,,	48	
27 ,,	...	...	,,	1 ,,	56	
30 ,,	...	...	,,	3 ,,	59	
1 May	...	. .	,,	1 ,,	60	
3 ,,	...	...	,,	2 ,,	62	
4 ,,	...	...	,,	1 ,,	63	
5 ,,	...	...	,,	2 ,,	64	
13 ,,	...	...	,,	1 ,,	72	
27 ,,	...	...	,,	1 ,,	86	
			35	55		

Result: 1 fertile egg.

Average life: males, 15·6 days; females, 32·5 days.
Longest ,, ,, 32 ,, ,, 86 ,,

Experiments Nos. XLVI. and XLVII.

FERTILITY OF MALES AND THE SURVIVAL OF SPERMATOZOA IN THE SPERMATHECÆ OF THE FEMALE (*STEGOMYIA FASCIATA*).

In these experiments, Nos. XLVI. and XLVII., the main object was to determine how many females a single male is able to impregnate and the scope of the ability to fertilize eggs which is imparted.

The longest time between pairing and the laying of fertile eggs which was observed during the progress of the research was 62 days—on the part of the female used in Experiment No. VII. This period was but a portion of her active productive life; while it lasted she laid 711 eggs in 15 batches. Subsequently she lived a further 29 days and laid 6 batches, containing 89 infertile eggs. In another experiment (No. XLI.) fertile eggs were laid 40 days after impregnation, which had been effected prior to the only meal of blood the insects received.

Neither of these cases can compare with Goeldi's classic example of the retention of spermatozoa for 102 days; nor are they, strictly speaking, comparable, because Goeldi's specimen only received the meal of blood necessary for the development of her eggs towards the close of her segregation.

Three experiments were attempted; the first was a complete failure owing to the escape of the male after pairing with two females. The second trial came to an untimely end with the death of the male after 7 days, during which period he fertilized 4 out of 5 females placed with him on successive days.

The third attempt promised better success, as the male lived 21 days and fertilized, more or less effectually, 10 of the 21 females that were placed with him. The females, however, proved to be very poor egg producers and of low vitality generally. This may have been due to underfeeding in the larval stage, as they were drawn from a very large brood at a period of the research when the amount of food required by the larvæ had not received proper attention. On the other hand, the small egg-laying capacity may have been a matter of heredity. It was certainly not due to want

of food in the adult stage, as they all had nightly opportunities, and, for the most part, fed as regularly as females which laid much larger batches of eggs.

Another factor which acted to the detriment of the experiment was attacks by ants. It was only towards the close of the series that it was discovered that inequalities in the rims of some of the jars used allowed the small yellow house ants, *Monomorium pharaonis L.*, to gain entrance. The disappearance of females and possibly a considerable percentage of the mortality is to be ascribed to this cause. If, however, the second and third attempts (Experiments Nos. XLVI. and XLVII.) are considered in conjunction, a fair idea of the scope of the males' ability in the matter of impregnation will be obtained.

Some allowance must be made for mortality among the fertilized eggs, which did not perhaps receive the most favourable treatment, but this source of error was minimised as far as possible by dissecting those eggs which failed to hatch on re-immersion after three months' dry storage, the number of those which contained developed larvæ being added to those which had already hatched. In several instances *living* larvæ were extracted from the eggs, but in most cases they were dead. In doubtful cases where full development of the larvæ was not demonstrated by the presence of the egg breaker on its head, the eggs were passed as infertile.

An appended table gives the record of the eggs laid by female No. III. in Experiment No. XLVI. in full detail.

Experiment No. XLVI.

FERTILITY TEST WITH *STEGOMYIA FASCIATA*.

The *male emerged 25th October, and died 1st November.

The females after feeding were placed with the male in rotation.

Female.	Date of emergence.	Date with male.	Started to lay.	Batches of eggs laid.												Total number laid.	Number of eggs which hatched or developed to larvæ in the respective batches.												Total number hatched.	Percentage of fertilized eggs.	Close of experiment.
				1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12			
I.	24 Oct.	25 Oct.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5 Dec.
II.	25 ,,	26 ,,	30 Oct.	9	35	...	...	...	...	...	...	...	...	...	...	44	2	13	...	...	...		...	...	...	...	...	...	15	34	3 Nov.
III.†	27 ,,	27 ,,	30 ,,	91	86	80	59	85	86	77	84	63	53	41	32	837	86	55	73	50	63	67	76	76	51	42	4	28	680	81	3 Dec.
IV.	27 ,,	28 ,,	8 Nov.	5	28	77	...	...	...	...	...	...	...	...	...	110	4	28	23	...	...	...	...	...	...	...	...	...	55	50	14 Nov.
V.	27 ,,	29 ,,	2 ,,	15	40	84	...	...	...	...	...	...	...	...	...	130	0	0	3	...	...	...	...	...	...	...	...	...	3	2	21 ,,
VI.	30 ,,	30 ,,	14 ,,	9	...	...	...	...	...	...	...	...	...	...	...	9	0	...	...	...	...	...	...	...	...	...	...	...	0	...	15 ,,
																1,139													753	66	

* Bred from egg laid 14th September, which was immersed until 15th October without hatching, was then dried and returned to the water: it hatched the same day: the larva pupated 23rd October.

† Detailed account of hatching appended.

REMARKS.—I., died without egg laying, although she fed well at frequent intervals; II. and III., found dead; IV., killed through an accident; V. and VI., found dead.

DETAILS OF THE LAYING AND HATCHING OF THE EGGS OF FEMALE No. III.

NOTE.—The number of eggs laid each day are given, and not in batches as in the experiment itself. The method employed was to allow the eggs to incubate in glass tubes on damp paper for from 2 to 5 days, the tubes being uncorked to allow gradual drying after the second day. Eggs immersed within two days were not dried at all.

Date of laying.	Number laid.	Reference number.	Dates of hatching.																									Total number which hatched.	Percentage which hatched.	Living larvæ extracted from eggs 30th April	Dead larvæ extracted from eggs.	Percentage of fertility.
			November.																			December.									
			1	2	3	4	5	6	8	9	11	12	13	16	17	18	19	21	26	27	29	30	2	3	4	8	15					
30 Oct.	91	1	1	30	3	40	10	2	...	...	...	...	...	...	..		...	...	...	...	...	...	...	...	...	...	...	86	95	...	...	95
1 Nov.	2	2	...	...	2	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	2	100	...	...	100
2 ,,	84	3	...	...	...	1	...	46	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...	...	...	1	53	63	...	..	63
5 ,,	80	4	...	...	...	...	...	...	54	11	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	67	84	..	6	91
8 ,,	59	5	...	...	...	...	...	...	...	...	34	24	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	59	100	...	...	100
11 ,,	84	6	...	...	...	...	...	...	...	...	...	...	...	34	5	...	...	...	...	...	...	...	...	...	...	...	...	39	42	...	24	75
12 ,,	1	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	...	...	...	...
13 ,,	2	8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	...	...	...	...
14 ,,	84	9	...	...	...	...	...	...	...	..	...	...	...	...	...	27	31	...	...	...	...	...	...	...	...	...	...	58	69	1	8	78
17 ,,	77	10	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	76	...	...	...	...	...	...	...	...	...	76	98	...	...	98
20 ,,	84	11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	75	1	...	..	...	...	...	...	...	76	90	...	...	90
24 ,,	63	12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30	2	...	...	...	...	...	32	51	1	18	81
27 ,,	53	13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	42	...	...	...	42	79	.	...	79
30 ,,	41	14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	...	...	4	10
3 Dec.	32	15	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28	...	28	87	...	...	87
	837																											618	73	2	60	81

NOTES.—1. On the 4th November the batch was dried and again immersed. 3. On the 2nd December the batch was placed in the rain and afterwards immersed in cool rain water. 4. When immersed on the 8th November several hatched within 5 minutes and 54 within one hour. On the 2nd December the batch was placed in the rain and afterwards immersed in cool rain water. 5. When immersed on the 11th November 34 hatched within 2 hours. 9. When immersed on the 18th November 23 hatched within one hour.

Experiment No. XLVII.

FERTILITY TEST WITH *STEGOMYIA FASCIATA*.

The male emerged on the 1st November, and died on the 22nd of the same month. The females were fed twice or thrice before they were placed with the male, one, two, three or four being put into the cage with him at the same time and left for two or three days.

Female.	Date of emergence.	Dates with the male.	Started to lay.	Batch of eggs laid. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total number laid.	Numbers which hatched or developed to larvæ in respective batches. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total number fertilized.	Percentage of fertile eggs.	Close of experiment.
I.	30 Oct.	1– 4 Nov.	7 Nov.	30	31	18	37	20	17	2	26	21	23	16	...	...	...	242	24	17	9	10	10	14	0	0	11	14	0	...	...	133	55	16 Dec.
II.	30 ,,	1– 4 ,,	11 ,,	4	...	...	...	...	...	...	...	...	...	...	...	...	...	4	0	...	...	...	...	...	...	...	...	...	...	...	...	0	...	19 Nov.
III.	30 ,,	1– 4 ,,	4 ,,	24	...	...	...	...	...	...	...	...	...	...	...	...	...	24	0	...	...	...	...	...	...	...	...	...	...	...	...	0	...	13 ,,
IV.	3 Nov.	4 6 ,,	9 ,,	71	52	63	11	69	...	...	...	...	...	...	...	...	...	266	68	48	63	9	68	...	...	...	...	...	...	...	...	256	96	23 ,,
V.	3 ,,	4 6 ,,	8 ,,	12	26	28	47	50	...	...	...	...	...	...	...	...	...	163	9	11	24	45	35	...	...	...	...	...	...	...	...	124	76	27 ,,
VI.	5 ,,	6 8 ,,	15 ,,	7	...	...	...	...	...	...	...	...	...	...	...	...	...	7	0	...	...	...	...	...	...	...	...	...	...	...	...	0	...	17 ,,
VII.	5 ,,	6– 8 ,,	13 ,,	16	...	...	...	...	...	...	...	...	...	...	...	...	...	16	11	...	...	...	...	...	...	...	...	...	...	...	...	11	69	13 ,,
VIII.	5 ,,	6– 8 ,,	11 ,,	17	36	...	...	...	...	...	...	...	...	...	...	...	...	53	1	0	...	...	...	...	...	...	...	...	...	...	...	...	1	2	13 ,,
IX.	5 ,,	8 11 ,,	15 ,,	2	54	16	7	23	24	27	20	14	6	3	0	25	...	236	1	42	1	0	0	0	0	0	0	0	0	0	0	...	44	19	12 Jan.
X.	8 ,,	11 14 ,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16 Nov.
XI.	8 ,,	11 14 ,,	14 Nov.	2	16	16	20	26	...	...	...	...	...	...	...	...	...	80	0	1	0	0	0	...	...	...	...	...	...	...	...	1	1	29 ,,
XII.	8 ,,	11 14 ,,	24 ,,	34	1	...	...	...	...	...	...	...	...	...	...	...	...	35	0	0	...	...	...	...	...	...	...	...	...	...	...	...	0	...	4 Dec.
XIII.	11 ,,	14 17 ,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30 Nov.
XIV.	11 ,,	14 17 ,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7 Dec.
XV.	11 ,,	14 17 ,,	10 Dec.	1	1	1	2	2	...	...	...	...	...	...	...	...	...	7	0	0	0	2	2	...	...	...	...	...	...	...	...	4	57	10 Jan.
XVI.	11 ,,	14 17 ,,	20 Nov.	24	...	...	...	...	...	...	...	...	...	...	...	...	...	24	0	...	...	...	...	...	...	...	...	...	...	...	...	0	...	21 Dec.
XVII.	12 ,,	17 20 ,,	21 ,,	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1	0	...	...	...	...	...	...	...	...	...	...	...	...	0	...	22 Nov.
XVIII.	12 ,,	17 20 ,,	29 ,,	1	1	7	...	...	...	...	...	...	...	...	...	...	...	9	0	0	0	...	...	...	...	...	...	...	...	...	...	0	...	27 ,,
XIX.	15 ,,	20 22 ,,	3 Dec.	47	...	...	...	...	...	...	...	...	...	...	...	...	...	47	9	...	...	...	...	...	...	...	...	...	...	...	...	9	19	4 Dec.
XX.	17 ,,	20 22 ,,	25 Nov.	1	1	2	4	9	8	11	11	...	...	...	...	...	...	47	0	0	0	0	0	1	0	...	...	...	...	...	...	1	2	7 Jan.
XXI.	17 ,,	20 22 ,,	26 ,,	3	...	...	...	...	...	...	...	...	...	...	...	...	...	3	0	...	...	...	...	...	...	...	...	...	...	...	...	0	...	26 Nov.
																	Total ...	1,264													Total ...	584 = 46 per cent.		

REMARKS.—I. to III., found dead; IV., disappeared, ? carried off by ants; V., escaped while feeding; VI. to XV., found dead; XVI., found dead, eggs abnormally small; XVII., disappeared, ? carried off by ants; XVIII. and XIX., found dead; XX., disappeared, ? carried off by ants; XXI., ants caught in act of devouring her.

Experiment No. XLVIII.

ENEMIES IN THE ADULT STAGE.

The most serious dangers to which adults of *Stegomyia fasciata* are exposed are probably those which arise from climatic causes. The daily rise of temperature, even in fine weather, is by no means excessive in Freetown, but it is sufficient to impart a considerable drying capacity to the air. During the dry season the dangers of desiccation are increased, while the incidence of the harmattan periods with strong, dry N.E. winds causes an enormous mortality among captive mosquitoes. Wild specimens, however, by seeking refuge either in crannies and crevices, or among moist vegetation out of doors or in dark recesses and corners within buildings, near floor level, away from any draught, can make local adjustment in their resting situations to minimize the danger. It is relative to this habit of seeking cover that the attacks of predaceous foes are most likely to occur, and, as a consequence, wingless enemies, such as toads, lizards, spiders, ants, scorpions and, possibly, also young mantids, probably take a heavier toll than do birds or flying insects, such as dragon flies; although the last named will almost certainly account for a certain number at the period when the mosquitoes leave the water and first take wing.

The habit which is so noticeable in resting *Stegomyia* of raising the third pair of legs and keeping them in constant motion, is probably a safeguard against attacks by wingless enemies, more especially ants. The elevation and movement of these legs will prevent their being easily seized hold of and they are available for an immediate kick-off, kangaroo fashion, at the slightest touch. When *S. fasciata* are deprived of their wings it at once becomes evident how considerable their leaping powers are. Two species of ants, *Monomorium pharaonis* L. and *Solenopsis geminata* F., proved themselves to be most inveterate enemies to captive mosquitoes during the progress of the research, and, as they appeared omnipresent in Freetown, mosquitoes are probably only safe from their attacks when actually flying.

In the mosquito house a small species of web-spinning spider, *Uloborus feniculatus*, and a larger species, belonging to the genus *Araneus*, which did not spin a regular web, took a heavy toll of the *S. fasciata* which were breeding in it. These spiders found entrance, when very small, through the 16 × 16 wire gauze and colonized it, breeding inside, using the corners and angles and covering the surface of the sides with their webs. The mosquitoes certainly formed their staple food, and, so far as observation of the captives in their webs went, were their sole source of supply.

Another uninvited guest in the mosquito house was a small species of scorpion, *Isometrus maculatus*, much flattened and with very slender claws. This must have found entrance through the crevice of a close-fitting, bevelled door when young, and possibly bred inside the house. From the slender, delicate structure of its pincers it is probable that it feeds on small insects only. A specimen kept in a 2-inch entomological glass-bottomed box was fed entirely on active adults of *S. fasciata*. It would capture and eat the entire number put into the box each night; sometimes disposing of 50 or 100 in a single night and, apart from its moulting periods, seems to have an insatiable appetite.

Small mantids in their first or second instars found their way into the mosquito house and were also found to capture and greedily devour specimens of *S. fasciata* when confined with them in a small box.

Two species of wall-hunting lizards were also tried; both were very young, considerably less than half grown. One, a species of *Lacertidæ*, probably *echinata*, cleared a large cage of *S. fasciata* with great despatch, but the other, a baby specimen of a gecko, probably *Hemidactylus brookii*, or one of its relations, only ate occasional specimens when they were placed in a small box with it, and made no appreciable difference to the numbers of mosquitoes in a large cage.

IV. PARASITES.

The larvæ and pupæ of *Stegomyia fasciata* reared in the mosquito house were found to be heavily infected with a species of gregarine, which has subsequently been identified by Dr. C. M. Wenyon as *Lancastriara culicus* Wenyon. This gregarine was found by Mr. A. C. Stevenson and Dr. C. M. Wenyon in specimens of *S. fasciata* reared from eggs laid upon leaves which were forwarded from Freetown for exhibition at one of the meetings of the Yellow Fever Commission.

The life cycle of this species has been thoroughly worked out by Wenyon (1911) in specimens of *S. fasciata* captured and bred at Bagdad, a fully illustrated account being published in "Parasitology," Vol. IV. 1911. From Stevenson and Wenyon's account of the gregarines in the specimens reared from the Freetown eggs and the experiments carried out by myself at Freetown, it is evident that the sporocysts are able to resist desiccation, and, like the eggs of the mosquitoes they infect, lie over the dry season in the dried-up water holes, awaiting ingestion by the larvæ which hatch out at the commencement of the rains. This habit of the parasite supports the view that *Stegomyia fasciata* relies chiefly, if not solely, upon the egg stage for the survival of the species during the dry period, as there would be no need for the sporocysts to have developed the ability to resist desiccation if the adult host survived the dry season in any numbers.

A trial carried out in order to test if infestation by the parasites had any checking influence on the development of the mosquito, or caused any mortality during larval life, showed no evidence of any ill effect on the development of the insect, nor was there any noticeable mortality in the larval stage. If any deaths at all occurred among the infected larvæ it was confined to the first or second instars.

The only other organisms detected in *S. fasciata* during the research were bacteria, which were present in small numbers in the larval gut and more plentiful in the stomachs of the adults, and some small oval bodies of from 2μ to 4μ in diameter, which were present in the stomachs of the adults. These were first noticed in smears of the dissected gut stained with Giemsa, and were suspected of belonging to the *microsporidia*, but sections failed to reveal any intracellular phases of the life cycle, nor could any undoubted evidence be obtained of their occurrence other than in the lumen of the gut. My colleague, Dr. H. M. Woodcock, of the Lister Institute, pronounced them to be yeasts.

V.—STERILITY OF THE PUPAL GUT OF THE *STEGOMYIA FASCIATA*.

In addition to the microscopic examination of the larval and pupal gut described on page 127, bacteriological tests were commenced in collaboration with Dr. G. G. Butler. Unfortunately, the trials had to be discontinued at an early stage of the investigation, owing to the calls of other duties on Dr. Butler's time.

A living pupa was allowed to swim for a few minutes in each of six tubes of sterilized distilled water—its transference from tube to tube being made with a sterilized platinum loop. The following tests were made in tubes of broth :—

	Result.
(*a*) An inoculation of water from the sixth tube ...	*Sterile.*
(*b*) The living pupa was allowed to swim in a tube of broth for five minutes	*Sterile.*
(*c*) The pupal gut with the malpighian tubes attached, was dissected out of the pupa and placed in a tube of broth	*Sterile.*
(*d*) The pupal envelope was placed in a tube of broth	*Sterile.*

Living pupæ were placed in a 1 per cent. lysol solution and allowed to swim about; they were all killed or rendered incapable of movement within fifteen minutes, but some became quiescent much sooner than others :—

	Result.
(*a*) A pupa was placed in 1 per cent. lysol for two minutes, its stomach was then dissected out and placed in a tube of broth...	*Sterile.*
(*b*) The malpighian tubes of the same pupa were placed in another tube of broth	*Sterile.*
(*c*) A pupa was placed in 1 per cent. lysol for five minutes, when it appeared to be dead; it was then transferred to a tube of broth for fifteen minutes and then removed	*Sterile.*
(*d*) A pupa that had been in 1 per cent. lysol for two minutes was dissected and the gut, with its appendages, placed in broth	*Sterile.*

Living pupæ were placed in 1 per cent. lysol for two minutes and then washed in sterile water :—

	Result.
(*a*) The gut was dissected out of the imago, which was ready to emerge from one of these pupæ, and placed in a tube of broth	*Growth of unidentified bacilli.*
(*b*) The gut was dissected out of a pupa, in which the imaginal development was not so advanced, and placed in a tube of broth	*Sterile.*
(*c*) An entire undissected pupa was placed in a tube of broth	*Growth of unidentified bacilli.*
The gut was dissected, with the usual precaution of sterilized needles, slides and salt solution, from an unsterilized pupa, and placed in a tube of broth	*Sterile.*

It seems more probable that the pupal gut is sterile, and that the cases of infection were due to some mischance in the technique than that the infecting organism had persisted in the gut from the larval period. Such a conclusion is supported by the microscopical examination of other pupal guts already alluded to. (*See* Experiment No. XXVII.).

VI.—NOTES RELATING TO THE LIFE HISTORY OF SOME NEAR ALLIES OF *STEGOMYIA FASCIATA* AND ASSOCIATED SPECIES.

Stegomyia sugens.

Larvæ of this species were obtained solely from rock pools.

The development of the larvæ is very rapid under favourable conditions, rigorous selection, consequent upon the habit of breeding in the smallest of rock pools, probably having compressed the larval period into the shortest space consistent with physiological requirements. In captivity the eggs incubate within two days.

Eggs.—(Fig. 1, page 18). The eggs, although very similar to those of *S. fasciata* in general appearance, are smaller, shorter, and more oval in outline, with traces only of the flattening side which gives the egg of *S. fasciata* its asymmetrical aspect. The average size of six eggs was ·573 mm. in length and ·176 mm. in width, the smallest being ·530 mm. by ·176 mm. in width, the largest ·590 mm. by ·180 mm. The surface is covered with the same delicate cellular reticulation, central bosses not noticeably different from those on the eggs of *S. fasciata* being present. The wall surrounding the micropylar area was a trifle more prominent in the eggs compared, and had a slight outward slope or overhang.

As regards the power of hatching within a few minutes of immersion, serial hatching, resistance to drought and response to cooling the eggs are, so far as the smaller amount of experimental work entitles one to say, as well and similarly endowed as those of *S. fasciata*. (See experiment which follows).

Hatching of Eggs of Stegomyia sugens.—Two females reared from larvæ taken in a rock pool at Murray Town. Emerged on or about 18th October, placed in a large cage with males and afterwards kept in a small jar. One female died after the first batch was laid, the second on the 8th November.

Date on which eggs were laid.	Number of eggs laid.	Date of hatching.														
		October.		November.										December.		
		29	30	3	11	13	19	20	21	22	23	24	12	20	21
27 October	100	5	3	5	3	...	7	2	1	7	8	1	1	34	4
4 November	20	...	...	..	...	2	...	...	...	...	...	...	...	2	3

Notes.—A portion of the first batch of 100 were immersed at once, while about one-third were allowed to dry and immersed a week later. When these dried eggs were immersed 5 hatched within 15 minutes Subsequently both portions were treated alike.

The eggs were kept immersed from the 3rd to 11th November without any hatching; they were then transferred to fresh water 2° F. below that they were in. Three hatched during the night.

On the 17th November a portion of the eggs were dried, placed in an incubator at 98° F. for several hours and thence into a desiccator; on the following day they were placed in a moist atmosphere and after 24 hours drops of water were gradually added, until the filter paper on which they were laid was saturated. They were then submerged in shallow water. 7 emerged within 30 minutes.

A second portion was dried without the use of incubator or desiccator, but otherwise treated similarly. None of the eggs hatched within several hours of their immersion.

A third portion was kept immersed without any alteration of the conditions. None hatched. On the following day the pan containing these eggs was placed in an ice chest, and the temperature of the water lowered by 6° F. One larva emerged within an hour and a second within three hours.

On the following day the cooling was repeated without effect but two emerged the next day. Also 5 hatched of the batch that had been gradually wetted and immersed, after drying without the use of incubator or desiccator, three days previously.

On the 20th December, all the eggs having been kept in water since the 12th December, they were lifted from the water and exposed to the very dry wind then blowing. After half an hour they were re-immersed in the same water. 26 hatched within 15 minutes and 8 more within the hour.

These larvæ fed up rapidly and produced normal adults, which fed, paired and laid eggs in due course.

The remaining unhatched eggs were dried on the 31st December and stored on the ground in the mosquito house until April when they were re-immersed. None hatched, and on the 12th May the few remaining eggs that retained their shape were dissected and found to contain dead larvæ. These eggs, like the stored eggs of *S. fasciata*, suffered from the attacks of *Psocidæ*.

It is possible that the humid storage does not suit *S. sugens* eggs, which, judging by the situation of the breeding pools, must be

capable of withstanding great extremes of heat and drought. Dried eggs have hatched within 15 minutes of their immersion, and the larvæ have grown to full size within three days. Pupation has occurred within four-and-a-half to five days, and adults have emerged within six days of the hatching of the egg.

Probably under favourable conditions in the natural state the time would be shortened, in fact, the appended note shows that it may be, but the specimens in this case were undersized.

Breeding of Stegomyia sugens in Small Rock Pools.

On the 5th May a small basin-shaped rock pool on Tower Hill (Plate No. 5, page 9) was found to be swarming with larvæ of *Stegomyia sugens*. The pool, which was capable of holding about one litre, had a small amount of muddy sand at the bottom, and was fully exposed to the sun, situated on a large bare convex rock.

The larvæ were all of a size either already in their third skin or about to moult for the second time. As from its size and shape the pool did not seem capable of resisting more than two successive dry days, it was kept under observation. The following day was sunny, and by 5 p.m. more than half the water had evaporated. As a number of *S. sugens* were required in order to obtain eggs, about half the larvæ and water was taken. (Within a week 88 male and 72 female specimens of *S. sugens* had emerged, also 3 females of *S. fasciata* and 1 of *S. luteocephala* from the larvæ taken from this pool.) It threatened to rain the same night, but the tornado passed with only a few drops of rain. The next day being fine and sunny, the pool was dried and the sand at the bottom got a thorough baking, the shade temperature being 85° F. On the next night, the 8th, it rained steadily until daybreak and the pool was visited about 5.30 p.m., when it was found to contain numbers of young larvæ full grown in their first skins. There seems no doubt that these had hatched since the rain, as, apart from the baking which the pool had on the 7th, the fact that the larvæ were younger than those found in the pool earlier precludes any possibility of their being survivors of that brood. It is further certain that they must have hatched from resistant eggs lying in the hollow, as the interval between the commencement of the shower and the finding of the larvæ was not long enough to allow of the incubation of freshly laid eggs. On the evening of the 11th the water was again very low; development had, however, been extraordinarily rapid, a few of the larvæ having already pupated (within

three days of hatching), but they were distinctly small for the species. On the 12th the water had evaporated, but both larvæ and pupæ were found to be alive in the wet mud and became fully active in water. Heavy rain fell on the night of the 12th and saved the survivors from the fate of the earlier hatched members of the brood.

Adults.—No wild adults were obtained or seen. Experiments with bred specimens reveal it as an equally greedy and persistent feeder on human blood as its cogener *S. fasciata.* It, has, however, many traits which suggest it to be less domesticated than *S. fasciata*, which shows the laxness of pairing and feeding habits which so frequently occurs with animals brought into close relationship with man. Mating could only be obtained by the use of a large cage; it was not witnessed, and apparently only took place at night, while feeding during the daytime could only be induced by darkening the cage. Feeding was, however, quite dissociated from pairing, as virgin females kept in small boxes fed readily and repeatedly, sometimes to such excess that they voided the surplus blood, apparently quite undigested. Under these conditions small numbers of infertile eggs were laid, and the length of life of some of the specimens was over a month.

A subsequent trial with a larger number, including males, was made at the close of the rains, the insects being kept in a large cage because fertile eggs were not obtained when they were kept in small cages. In this case the length of life was shorter, there being a very heavy mortality within a few days of emergence. Not more than two batches of eggs were laid by segregated females, but this does not probably represent the limits of fecundity. Feeding would seem to be adjusted in relationship to egg laying, as with *S. fasciata*, taking place on successive nights, but being refused just prior to oviposition. No exact figures as to the number of eggs laid by a single female were obtained, but two females laid over 100 in a single night.

Stegomyia simpsoni.

Larvæ of this species were obtained from water holes in a cotton-wood tree, and a number were reared from a mass of leaves taken from the same holes during the dry season. A very general breeding place would, however, seem to be in small collections of water in the axils and whorls of leaves of the coco yam, cock hat tree, a species of *Dracæna* (*see* Plates 16 and 17, page 17), and banana.

Only infertile eggs were laid by captive females. (*See* Fig. 1, page 18.) These, while generally similar to those of *S. fasciata*

and *S. sugens* in colour, shape, size and surface structure, differ in several minor points. They are smaller and slightly more slender than those of *S. fasciata* and bilaterally symmetrical, while the micropylar wall is lower and less evident than that of *S. fasciata*. The measurement of two or three eggs gave the size as about ·550 mm. in length by ·120 mm. in thickness.

In the absence of fertile eggs laid by captive females it was not possible to follow up the larval life in detail, or carry out any experiments regarding the endowments of the eggs in respect of resting, serial hatching and response to external *stimuli*. That the eggs are drought-resisting, and that the species depends upon tiding over the dry season in the egg stage seemed obvious, but the record of rearing from leaves stored dry (see Notes on page 148) sets the fact beyond doubt. Time did not permit of searching the leaf axils of plants during the dry season for resting eggs. Failing their discovery in such situations, it remains to be proved whether the species uses these situations as auxiliary to water holes in trees, or if it can exist indefinitely when dependent upon leaf collections of water alone.

Adults.—The insects fed readily at night on human blood and to a limited extent in a darkened cage by day. They were individually almost, if not quite, as greedy as *S. sugens* or *S. fasciata*. As only infertile eggs were laid and these only at long intervals, though in fairly large batches, it is to be presumed that pairing did not take place in spite of the fact that various expedients were tried, and that a number of both sexes were kept together in a large cage. No attempts at pairing were witnessed. The length of life was not determined with any accuracy, but some of the females certainly lived for more than a month during September—October.

Stegomyia luteocephala.

This species was obtained in the larval stage chiefly from water holes in the roots of cottonwood trees, though a few were taken in rock pools of similar size to those affected by *S. sugens*.

Collections of water in tins or other utensils yielded larvæ at rare intervals, while a single specimen was reared from the coco yam.

Eggs.—(*See* Fig. 1, page 18). Infertile eggs approximate closely to those of *S. fasciata*, but are slightly smaller than the average eggs of this species. The girth is greater in relation to the length and the taper to the ends is consequently more marked, while the flattening of one side, which gives a slight asymmetrical outline to

S. fasciata from certain aspects, is accentuated. In the particular eggs compared there was a slight difference in the cellular reticulation, the walls in *S. luteocephala* appearing higher in relation to the central bosses, while the micropylar wall was lower. In the absence of fertile eggs no experimental work was carried out, but on the evidence obtained by rearing the species from a collection of dried leaves taken from a root hole it is possible to say that the eggs are undoubtedly endowed with similar drought-resisting powers to the other species of the genus already dealt with. On two or three occasions considerable batches of infertile eggs were laid by bred females on wet filter paper or wet wood (this latter seemed more attractive), but the majority of the females either died without ovipositing or laid only a few eggs at irregular intervals.

The larvæ, like those of *S. fasciata*, appear able to survive without water if kept moist. A larva was found among wet leaves in a small water hole ; its skin was already dry where exposed to the air, and it was incapable of movement. On immersion it recovered and a male specimen was reared.

Adults.—Like the other species of *Stegomyia* the females fed readily and vigorously on human blood, and were less disinclined to bite by day in a darkened cage than either *S. simpsoni* or *S. sugens*. Numerous attempts were made to induce the insects to pair, glass jars as well as small and large wooden cages being used. No attempts at pairing were observed, and it is to be presumed, as infertile eggs were laid on several occasions by the females, that copulation did not take place. The length of life was not accurately determined, but the females lived in captivity for several weeks.

Ochlerotatus apicoannulatus.

Specimens were reared from larvæ taken in water holes at the roots of trees, in rock pools and occasionally from water in tins. Many attempts were made to pair the insects and obtain eggs. Although the insects lived for two or three weeks in captivity, and the females bit fairly frequently, it was only occasionally that they filled themselves with human blood. In several instances, however, the same individuals fed several times. Towards the close of the dry season specimens were reared from a collection of fallen leaves taken from water holes at the roots of a cottonwood tree. These were placed in a large cage kept dark and moist by hanging wet clothing over it, and one or two of the females fed greedily by day on a human arm.

No attempts at pairing were observed and no eggs were laid.

Ochlerotatus minutus.

This species was reared from larvæ taken in numbers from rock pools, old tins and water holes at the roots of trees towards the close of the rains. Numerous attempts were made to get the insects to pair and oviposit, but they were unsuccessful. The females bit frequently, and sometimes fed well on human blood.

Uranotænia ornatus.

This species was reared from larvæ taken exclusively in the water which collects in the whorls and axils of the leaves of plants; many attempts were made to feed, pair and obtain eggs, but they were all unsuccessful, and the insects never lived more than 36 hours in captivity. The females never attempted to take human blood or betrayed the slightest inclination to bite, nor were they observed to feed on the honey provided for them.

Eretmopodites.

Three species of this genus were taken in the larval stage; *E. quinquevittatus* from collections of water in tins, etc., in some numbers; *E. chrysogaster* sparingly from the same situations; and *E. draconis* commonly from collections of water in the whorls and axils of the leaves of various plants. The close similarity in general appearance and colouration of the species is very puzzling, and makes the segregation of active individuals for pairing purposes a matter of chance. The males of *E. chrysogaster* are easily determined by the tufts on their hind legs, but as regards *E. quinquevittatus* and *E. dracænæ* the only easy mode of determination is by an examination of the pupa. The females of *E. quinquevittatus* and *E. dracænæ*, and possibly those of *E. chrysogaster*, fed at irregular intervals on human blood until their stomachs were distended to an extent which greatly detracted from their elegant beauty. A number of specimens bred from a collection of larvæ were kept in H.L.C. cages and given nightly opportunities of feeding on human blood, honey being placed in the cages for the males. Occasionally they were all turned loose for a few nights into a large cage, the females being segregated afterwards for oviposition. Most of the specimens were *E. quinquevittatus*, but males at least of *E. chrysogaster* were also present. A small number of eggs were laid in twos and threes; although there was no difference in colour or structure, there was a striking divergence in shape and size; and as they

segregated into three sizes the eggs were reared in separate jars, but the pupal stage showed conclusively that all the eggs were all those of *E. quinquevittatus*.

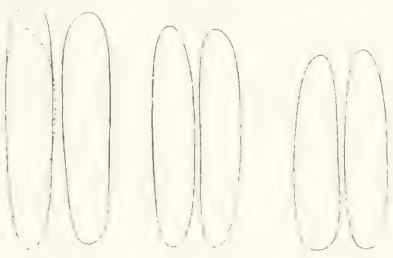


Fig. 3.

Outlines of eggs of *Eretmopodites quinquevittatus*, showing the wide variation in size which exists in the eggs of this species. Adults were reared from all the eggs. The dotted outline shows an egg of *Stegomyia fasciata* for comparison.

Both sexes were reared from the short eggs, and a pairing was watched in a H.L.C. cage ; the male came to the female while she was resting. The blood-sucking propensities of the bred specimens were as erratic as those of their parents, and biting was more frequent than actual feeding. Though the insects were hardy and bore confinement well, they did not live long—about three weeks being the average time, the longest life not being more than a month.

Eggs of E. quinquevittatus.—These were almost invariably laid horizontally, on the sides of the jar or on pieces of wood, just beneath the water surface, and the firmness of their attachment suggested the use of some cement. A small batch laid on the 12th October was divided, some of the eggs being dried and the others immersed in a pan of water. Those taken from the water all collapsed on drying while the others hatched. Unfortunately, no opportunity of repeating the experiment occurred, but the suggestion is that the eggs of this species are not drought resisting, and this is possibly supported by the fact that all the eggs previously laid hatched within a few days of laying, there being no cases of serial hatching or resistant eggs.

The eggs differ markedly in appearance from those of *Stegomyia* ; they are bright brown in colour, the shell looking thinner and more

delicate. In shape they are longer and more cylindrical, with rounded rather than pointed ends, only the slightest trace of asymmetry being discernible at the micropylar end. The large eggs are nearly a third longer than those of normal *S. fasciata*, about ·8 to ·9 mm.; the medium sized about one quarter larger, about ·750 to ·780 mm., while the small eggs are scarcely, if at all, larger than normal eggs of *S. fasciata*—being about ·630 to ·650 mm. in length. These short eggs were, however, thicker than the medium sized ones, and relatively thicker than the long ones. Actually they were not quite so thick. The surface is smoother than that of the *Stegomyia* eggs, the cellular reticulation being more delicate, while the central area of the cells is slightly raised, or puffed, to use Mitchell's term. The appearance of the empty shell suggests, however, that the raised areas are structural features of the egg-shell, and not pockets containing a separate substance as in *Stegomyia*. In the absence of sections, however, it is not possible to speak with certainty on this point. All three forms of egg produced normal adults, the only observed differences being in regard to date of hatching and development of larvæ, the short eggs taking five or six days to hatch as against two or three in the case of the larger eggs; while the larvæ which emerged from them fed up more rapidly, but as the larvæ were kept in separate jars this may have been due to variation in food.

Larvæ.—The larvæ of these species are long, slender, even in comparison with those of *Stegomyia*, and of pale colouration. They show traits of ground feeding, moving over the sides and bottom of the jar with a walking or gliding movement, browsing as they go. This habit is also very noticeable with young larvæ of *Stegomyia fasciata*, but it gradually becomes less noticeable as they grow older, whereas it is characteristic of the larvæ of *Eretmopodites* when fully grown.

Pupæ.—In this stage *Eretmopodites* exhibit some marked divergencies from other mosquito pupæ, and also vary widely within the group. The abdomen is larger and longer in relation to the thorax and less curved, rendering the pupæ as a whole straighter and less "comma"-like than the other mosquito pupæ dealt with in this Report. The paddles are relatively small and heavily fringed with hairs, while in *E. quinquevittatus* the reduction in size is so marked, and the importance of the hairs on the apex of the paddles and terminal segments of the pupæ are so exaggerated, that it appears, superficially at any rate, to differ more from its fellow species within the group

than the genus as a whole does from *Stegomyia* in respect of pupal characters. (*See* Figures on pp. 142 and 144.)

Adults.—As already noted, these extremely beautiful and elegant insects are certainly blood suckers. It is, however, doubtful if man is the normal host. Specimens given honey and water and banama lived for two or three weeks, although they were never observed to feed on the foods given them. They have a characteristic habit of wandering about and carefully probing with their slightly curved proboscis the surface of wood and glass, as though searching for minute drops of moisture.

VII.—NOTES REGARDING THE POSSIBILITIES OF THE PUPAL PADDLES (ANAL PLATES OF WESCHÉ) FOR PURPOSES OF CLASSIFICATION AND THE SEPARATION OF ILL-DEFINED SPECIES.

An examination of the pupa cases of the species of *Stegomyia*, *Eretmopodites*, and other mosquitoes bred at Freetown during the course of the research, showed that very marked differences may occur in the pupal paddles of closely-related species. Though time did not permit of a full examination and detailed description being made of all the pupal characters, the divergence in shape and structure of these appendages* proved so convenient and easy a method of separating species closely resembling each other as do the females of *E. quinquevittatus* and *E. chrysogaster* that preparations and camera drawings were made of as many species as possible.

Incidentally this led to the discovery of a new species bred from collections of water in the central whorl and axils of the leaves of plants, which is described by Mr. F. W. Edwards under the name of *Eretmopodites draccænæ* Edw. in the "Bulletin of Entomological Research," Vol. VI., Part 4.

Although the divergence in structure between the paddles of *E. quinquevittatus* and those of the other species of the genus *Eretmopodites* is so remarkable, this would seem to be unusual, a slight difference, such as that existing between the various species of *Stegomyia* being more general; while, on the other hand, there may be a close approximation in character, as is the case with *Anopheles (Pyretophorus) costalis* and (*Myzomyia*) *funestus*. There seems, therefore, no likelihood, so far as the scanty material examined goes, that these characters could be made to afford the basis for an independent scheme of classification, such as has already been suggested on larval characters. On the other hand, these pupal appendages, which are obviously likely to be adaptive rather than ancestral in character, afforded so ready a means of discrimination in the above case that it seems worth while to call the attention of workers in this group of insects to their possibilities.

This appears to be the more necessary as Wesché (1910) in his paper dealing with the larval and pupal stages of the West African

* Wesché (1910) terms these fins "Anal Plates." The authors of the Carnegie Monograph (1912, etc.) refer to them as "Anal Paddles."

Culicidæ has scarcely done justice to the pupal characters. The species he treats of do not show any such striking differences as those between the various *Eretmopodites* referred to above, but, judging by the plates illustrating his article, insufficient magnification has been used and the representation of *Anopheles (Pyretophorus) costalis* is seriously in error as regards the character of the terminal hair or seta on the paddle, which is really strongly reminiscent of a boot-hook. (Compare Fig. 19, page 146, with fig. 6, plate VI., in Wesché's paper.)

It is somewhat remarkable also that Messrs. Howard, Dyar and Knab (1912) in their monograph of the Mosquitoes of North and Central America and the West Indies have made but slight use of the pupal paddles, while to my great disappointment, the magnificent plates illustrating this work show the pupæ only in lateral aspect.

Pending the description and figuring of a wider range of species, the characters afforded by the paddles can only be used in the same limited manner as at first supplied to the genitalia of insects generally, *i.e.*, as a test of separation in difficult cases. For this purpose the paddles of mosquito pupæ are readily available, as the pupa case can be examined under a low magnification and the paddles are all in one plane.

Permanent mounts are very easily made. The empty pupa case should be removed from the breeding jar as soon after the emergence of the adult as possible ; while it still floats is best. It is then spread on a slide, the wing, leg and thoracic portions of the case being separated and opened out if desired. A cover slip is dropped over it and tied down with fine cotton ; it can then be dehydrated in alcohol, transferred to xylol to clear, the thread cut off and balsam run in without disturbing its arrangement.

All the figures are drawn to the scale of 30 diameters, except that of *Toxorhynchites brevipalpis*, which, owing to its large size, has only been magnified x 10.

In several cases the setæ, though represented as simple, are actually branched, but so minutely that it was impossible to show this feature without gross exaggeration. The marginal fringes to the paddles would appear in all cases to be the development of a serrated edge, even when the fringe is very long, as with *Eretmopodites chrysogaster ;* the distinction between these tapering filaments and the round sectioned setæ on the abdominal segments, or the terminal ones on the paddles, is quite clear. In some cases, as with *Stegomyia sugens* and

Ochlerotatus apicoannulatus, the serrations are excessively minute and delicate. In most instances it was only practical to represent these fringes by single lines.

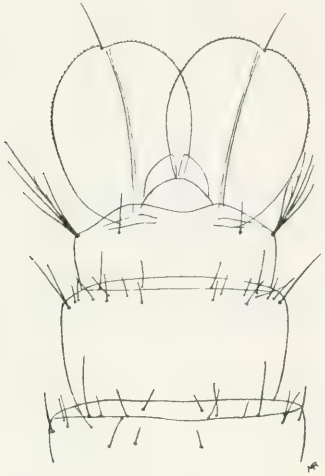


FIG. 4.

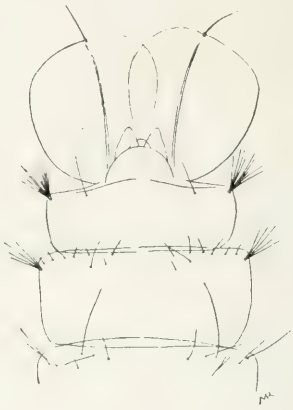


FIG. 5.

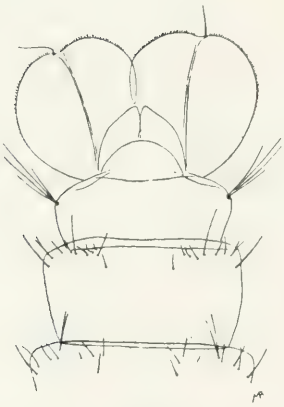


FIG. 6.

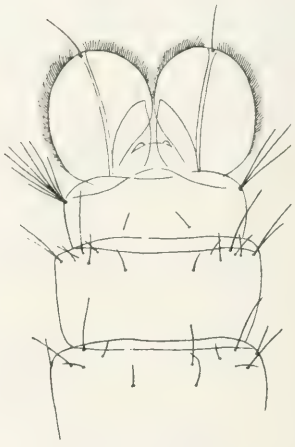


FIG. 7.

Figures 4, 5, 6 and 7 represent the paddles of *Stegomyia fasciata*, *sugens*, *simpsoni* and *luteocephala*. All four species show well marked differences, the marginal fringe in *fasciata* and *simpsoni* consists of delicate serrations. The asymmetry of the terminal lateral setæ on the eighth abdominal segment of *luteocephala* is rather noticeable, but is of course not a normal feature — asymmetrical divergence in the setæ of insects being by no means an uncommon phenomenon.

The paddles of *Ochlerotatus simulans* (Fig. 8), *apicoannulatus* (Fig. 9), and *minutus* (Fig. 10), though very similar in general appearance, each show one or more distinguishing features.

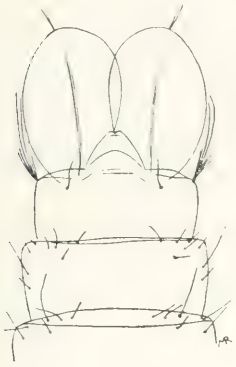


FIG. 8.

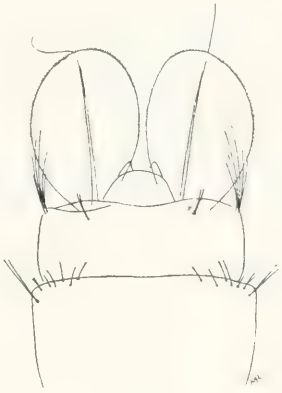


FIG. 9.

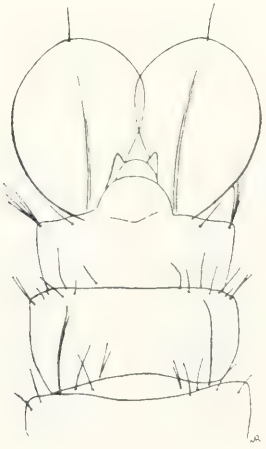


FIG. 10.

The four figures of the paddles of *Eretmopodites* are those of *quinquevittatus* (Fig. 11), *chrysogaster* (Fig. 12), *dracenae* (Fig. 13), and an undetermined specimen (Fig. 14). The heavily fringed paddles of the last three specimens, together with the extraordinary specialization of *quinquevittatus*, make the group a very interesting one as regards this character. Only a single specimen of the undetermined species

was obtained, and, owing to some mischance, the adult which emerged from it either escaped or was mislaid, and a specimen of *E. dracænæ* was by mistake associated with it.

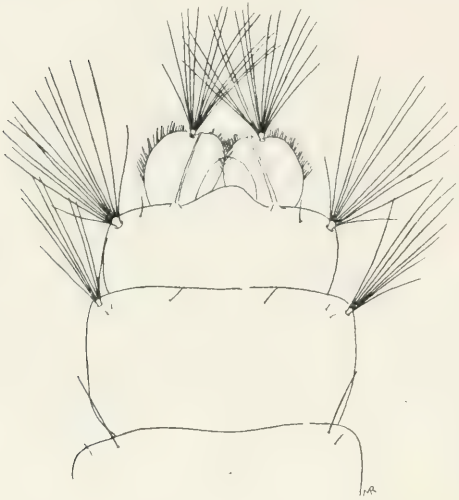


FIG. 11.

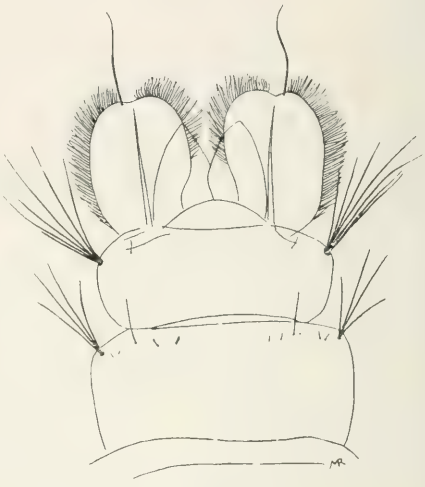


FIG. 12.

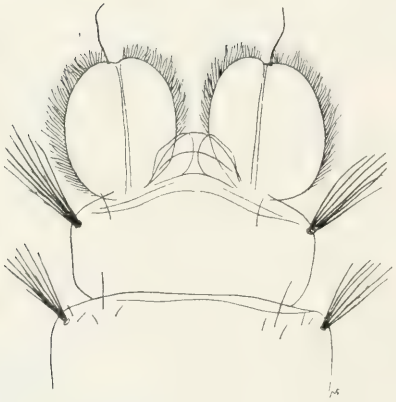


FIG. 13.

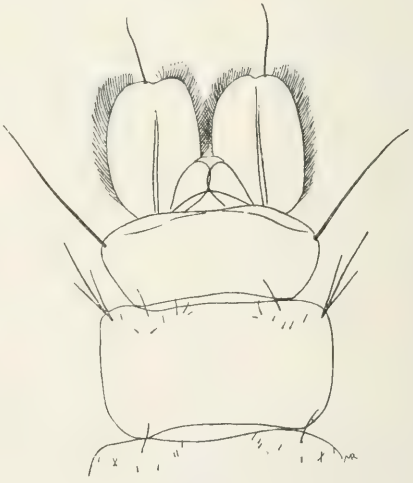


FIG. 14.

Uranotænia ornata (Fig. 15) was the only species of the genus taken; it has quite distinctive paddle characters.

Culex tigripes (Fig. 16) has broad fringeless paddles, with two small fan-branched lateral setæ on the eighth segment.

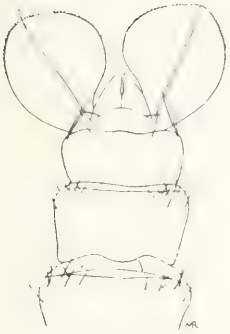


Fig. 15.

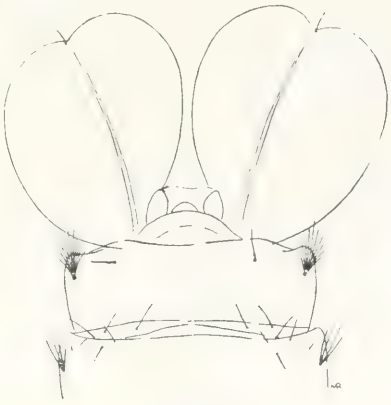


Fig. 16.

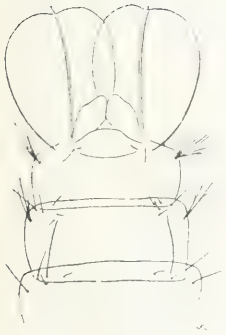


Fig. 17.

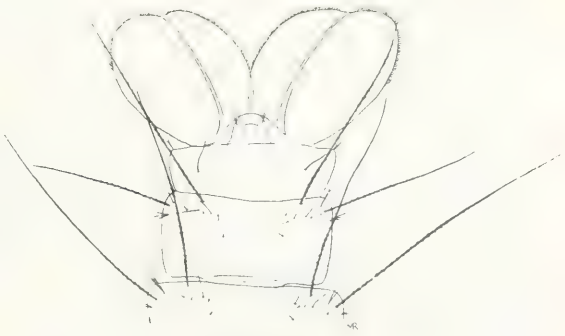


Fig. 18.

Culiciomyia nebulosa (Fig. 17) has much the same general type of paddles, but differs as regards these lateral setæ.

Toxorhynchites brevipalpis (Fig. 18).—The paddles of this giant species have no terminal spine; the lateral setæ on the eighth segment, which are specially developed on the other specimen figures, are small and inconspicuous, but certain dorsal setæ on the seventh and eighth abdominal segments are very long and markedly serrated.

Anopheles.—The only two species obtained were *Pyretophorus costalis* (Fig. 19) and *Myzomia funestus* (Fig. 20). They are almost identical in the character of the terminal segments and paddles, the only noticeable point of difference being that the lateral setæ on the eighth abdominal segment of *funestus* are larger, with less spread of the branches than in *costalis*. This difference is, however, rather more accentuated in the illustration than it should be.

FIG. 19.

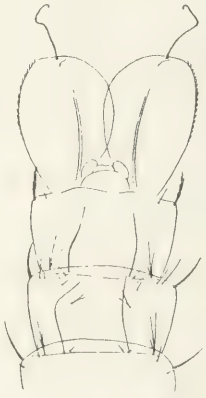


FIG. 20.

VIII.—NOTE REGARDING THE REARING OF SEVERAL SPECIES FROM DEAD LEAVES TAKEN FROM AN EMPTY WATER-HOLE DURING THE DRY SEASON.

In the early part of January a small number of fallen leaves in a dry water-hole at the root of a cottonwood tree were collected and examined for eggs (*see* Plates 1 and 2, p. 6). About thirty leaves were carefully examined under a binocular dissecting microscope. Eggs were found on several leaves; examples were sent home to be photographed by Mr. F. Noad Clark, and for exhibition at one of the meetings of the Yellow Fever Commission; these last were passed on to Mr. Malcolm Evan MacGregor, of the Wellcome Bureau of Scientific Research, who reared a number of specimens of *Stegomyia fasciata* from the eggs.* Specimens of *S. fasciata* were also reared in Freetown from eggs laid on one of the leaves.

PHOTOGRAPH OF EGGS OF *STEGOMYIA FASCIATA*.

Photo by F. Noad Clark. *Plate No. 23.*

Eggs of *Stegomyia fasciata*, laid on a leaf of Cottonwood tree. ×40.

* *Journal of Tropical Medicine and Hygiene.* "Notes on the rearing of *Stegomyia fasciata* in London," Vol. XVIII., No. 17, pp. 193–196.

During the latter part of January a further collection of fallen leaves was made from the dry water-holes* in the same tree, but, as time did not permit of their examination for eggs, they were left lying in a paper envelope on the laboratory bench. No opportunity for careful search having occurred by the 13th March, the leaves were placed in a new, carefully cleaned petroleum tin and about 5,000 cc. of tap water added. By the 15th March the water was swarming with larvæ of all sizes up to the third skin. A few were examined and found to be larvæ of *S. fasciata*. A number of dead cockroaches were placed in the tin on this date. On the 17th March (four days after the immersion of the leaves) about 30 pupæ were captured and transferred to glass jars. On the 18th a further 50 were caught in the tin; 9 males of *S. fasciata* emerged from the first batch of pupæ one-hundred-and-twenty-six hours after the leaves were placed in water. On the 19th, 37 more males and 4 females of *S. fasciata* emerged; over 100 specimens of both sexes emerged on the 20th March, and 1 male specimen of *S. simpsoni*; on the 21st March, in addition to *S. fasciata*, more specimens of *S. simpsoni* and a number of *S. luteocephala* and *Ochlerotatus apicoannulatus* emerged. There was rather a heavy death rate among the larvæ in the tin, due apparently to too large a number of cockroaches being added and causing a greasy scum.

The total numbers reared were:—

	S. fasciata.		*S. simpsoni.*		*S. luteocephala.*		*O. apicoannulatus.*	
	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.
March 18 ...	9	...	...	...		...	...	...
,, 19 ...	37	4	...	...	...	...	...	...
,, 20 ...	25	72	1	...	...	...	...	...
,, 21 ...	19	57	7	8	19	1	5	6
,, 22 ...	4	4	...	6	24	7	...	3
,, 23 ...	1	1	...	2	3	25	...	...
,, 24 ...	...	...	...	...	...	2	...	...
	95	138	8	16	46	35	5	9

* Although there was no water in the holes at this date, the matted mass of decaying leaves at the bottom was still moist; these were not disturbed, only the loose undecayed leaves being collected.

From this record it will be seen that *S. fasciata* is easily the quickest breeder, the average times being: *S. fasciata*, 7·1 days; *S. simpsoni*, 8·4; *S. luteocephala*, 9·1; and *O. apicoannulatus*, 8·2. Perhaps the chief point of importance in this breeding record is the proof it affords of the passage through the dry season in the egg state of *S. simpsoni*, *S. luteocephala*, and *Ochlerotatus apicoannulatus*.

A careful watch was kept on the breeding tin for larvæ that were expected to emerge from resistant eggs, but none occurred, although cooling was resorted to. It is a possible, if not a very satisfactory, explanation that the grease in the water from the cockroaches proved fatal to the late hatched larvæ.

IX.—METEOROLOGICAL CONDITIONS AS AFFECTING THE BREEDING AND DISPERSAL OF MOSQUITOES AT FREETOWN.

The character of the incoming rainy season, together with the tornadoes which herald its approach, is probably of great importance in this connection, as quite small divergencies may cause exaggerated effects in regard to the numbers and distribution of the various species.

The early tornadoes (which commenced on the 7th March) were frequently of the nature of dry squalls; if accompanied by rain at all it usually fell only towards the end of the blow. Their direction was generally from the E.S.E., travelling down the estuary of the Sierra Leone River and through the gap in the hills behind Mount Aureol. They were generally accompanied by clouds of dust; and insects, especially small ones, such as mosquitoes, would easily be caught up and carried by the wind like snowflakes, dropping to earth behind any shelter, such as the banks of the brooks, houses and streets of Freetown would afford.

Coincident with these squalls reports of mosquitoes on the shipping in the harbour occurred, also cases of fever. Specimens of *P. costalis*, *S. fasciata* and a number of *C. nebulosa* were received from Dr. Costello of the s.s. "Transmitter," which lay some 500 or 600 yards off shore.

Some of the most extensive breeding grounds (Kissy flats, *see* Plates 13, 14 and 15, pp. 14, 16) for the *Anopheles* mosquitoes lay a few miles up river S.E. of Freetown, so that an immigration of these species into Freetown during the season of these dry squalls is a possibility to be reckoned with; more especially is this the case, as the squalls generally take place at night, or just before daybreak, when mosquitoes are likely to be on the wing.

It is therefore of importance to the mosquito section of the sanitation of Freetown that the administrative area should be enlarged so as to include these outlying districts, and attempts made to confine the surface water to definite cuts, in place of allowing it to trickle out over the large, gently-sloping areas bordering the railway (*see* Plates 9, 10 and 13, pp. 12, 13, 14).

It is also specially important that attacks on possible mosquito breeding places should be commenced at the very onset of the rains. These are necessarily few in number, and restricted in area at this period, and might be scheduled, as they will consist of pools in the

beds of the deeper drainage gullies (*see* Plates 24 and 25), and hollows, empty water-holes and small dried-up ponds. Later, when the rains are heavier and the showers more frequent, all these places will be impossible as breeding situations, because the drainage gullies (natural or artificial) will form the beds of streams so torrential in

ROCK POOLS NEAR WILBERFORCE STATION.

Plate No. 24.

Rock Pools in roadside drain. During early May these pools swarmed with pupæ of *Stegomyia*; in June and July the constant rainfall kept them washed clear.

character that any larvæ or pupæ will be swept into the creeks, while the larger and more permanent pools will have attracted numbers of frogs and toads intent on breeding. The available breeding places of the mosquitoes change as the season advances, the number of collections of water being enormously increased, as even the slightest

hollows can be utilized when showers are constantly renewing the water in them (*see* Plates 4, 5 and 7, pp. 8, 9, 11). Very great risks of drying up are taken by the species, as the notes on *Stegomyia sugens* on page 132 will show, but mosquitoes, and especially *Stegomyia*, with its serial hatching eggs, are adapted to these precarious conditions;

MOSQUITO BREEDING POOL.

Plate No. 25.

Rock Pool in the gutter of Murray Town Road, which was tenanted by swarms of pupæ of *Stegomyia sugens*.

the constant dangers from predaceous enemies and competition by other organisms, whose life cycle is not so rapid, in the more permanent collections of water being of more moment to the species than the mortality arising from climatic conditions.

X.—EXPERIMENTS DEALING WITH THE DESTRUCTION OF *STEGOMYIA FASCIATA.*

Experiments dealing with the destruction of *Stegomyia fasciata* were limited to the egg, larval and pupal stages, and the use of simple and easily obtained articles—ordinary burning petroleum, soft soap, flake naphthalene and salt water (from the harbour)—one of the objects of the trials being to ascertain to what extent the eggs were destroyed by methods readily applicable to the larval stage. The tests carried out with emulsions were directed chiefly against the active larval and pupal stages, the attenuated quantities of emulsions used having but little effect on the resistant eggs.

No experiments were conducted with the adult insects, as with the limited time and means at my disposal the possibility of improving on the already recorded remedies and tested methods of applying them seemed remote.

In order to render the tests as strictly comparative as possible, the trials with the different substances were carried out at the same time, the eggs, larvæ or pupæ being taken from a common source, the test on eggs with petroleum-soft soap emulsion being an exception.

Experiment No. XLIX.

COMPARATIVE EFFECT OF SOFT SOAP AND PETROLEUM (1 IN 600) ON EGGS, LARVÆ AND PUPÆ.

300 cc. of tap water was placed into each of two large beakers of three-and-a-half inches diameter.

A portion of a large batch of eggs of *Stegomyia fasciata* recently laid on filter paper was then submerged in each of the beakers, and a number of active, well-grown larvæ and pupæ were also put in.

·5 cc. of petroleum (= 1 in 600) was dropped on the surface of the water in beaker *P.*, while ·5 gram of soft soap (= 1 in 600) was dropped into beaker *S.S.*

50 eggs of the same batch were placed in salt (harbour) water as a control.

Temperature of water about 80° F.

Within 1 hour most of the larvæ and pupæ were dead in both of the beakers.

After 20 hours.

Effect on eggs :—

P.—Some of the eggs have hatched and the young larvæ are swimming about.

S.S.—No young living larvæ are visible.

Salt Water Control.—A number of eggs have hatched and the young larvæ are dead.

The eggs were then removed from the water and halved, one-half being returned to the beakers and the other carefully examined under the binocular microscope :—

P.—4 eggs had hatched out of 61 examined.

S.S.—No eggs had hatched out of 68 examined.

These half batches were then dried and put into clean tap water to test the effect of 20 hours' immersion in petroleum and soft soap on them.

After 48 hours' immersion.

P.—Many more eggs have hatched and larvæ are living ; at least one has moulted.

Of the half removed to tap water, 28 have hatched and larvæ are living.

S.S.—Of the eggs left in the beaker, 31 out of 60 have hatched, but no living larvæ are visible, the water is too cloudy to admit of certainty as to all being dead. Of the half removed to tap water 39 have hatched, all of which are living.

Salt Water Control.—31 out of about 50 eggs put in have hatched; only one larva is living (it died shortly afterwards).

After 96 hours.

P.—The water still smells of petroleum, but the larvæ which hatched from the eggs are doing well.

S.S.—No signs of living larvæ.

Of the eggs removed from the beakers after 20 hours' immersion in water to which petroleum or soft soap had been added, all but two or three doubtfully fertile eggs have hatched.

In the salt water control 8 more larvæ have hatched and the larvæ are dead.

After 8 days.

P.—A large number of small, underfed but active larvæ are present. All the eggs have hatched.

S.S.—No living larvæ. All the dead ones found are in the first skin. A few unhatched eggs present. After drying and re-immersing these resistant eggs in clean water 13 hatched within two days, but about half the larvæ died shortly after emerging.

Conclusion.

Petroleum.—1 in 600 kills all larvæ and pupæ but fails to destroy the eggs, and the larvæ which hatch survive.

Soft Soap.—1 in 600 kills all larvæ and pupæ and also the young larvæ which hatch out from submerged eggs. It has no effect on eggs which have been submerged for 20 hours, but has detrimental effects on a proportion of those which have been submerged for 8 days.

Experiment No. L.

Second Trial.

CONTRASTED EFFECT OF PETROLEUM (1 IN 4,000), SOFT SOAP (1 IN 8,000), AND NAPHTHALENE (1 IN 8,000) ON EGGS, LARVÆ AND PUPÆ OF *STEGOMYIA FASCIATA*.

In this experiment thoroughly cleaned petroleum tins cut down to six inches in depth were used. The size of the tins is nine inches by nine inches with curved corners. Approximate surface area, 80 square inches.

4,000 cc. of tap water was poured into each tin and a portion of a large batch of eggs, laid three months previously on filter paper and stored dry, was submerged in the water. A number of active larvæ and pupæ from the breeding pans were also added.

P.—1 cc. of petroleum was dropped on the water in one tin.

S.S.—·5 gram of soft soap was dropped into another.

N.—·5 gram of flake naphthalene was scattered on the water of the third.

All the pans were covered with cheese cloth. Temperature of water about 80° F.

After 24 hours.

P.—11 adults have emerged and are living. The larger proportion of the larvæ and pupæ are dead, but a number are still living.

Eggs.—Large numbers of eggs have hatched; some of the young larvæ are dead but the great majority are active.

S.S.—15 adults have emerged and are living. Most of the pupæ and larvæ are still active but a few are dead.

Eggs.—Swarms of newly-hatched larvæ are swimming about. No dead observed.

N.—The pupæ seem to be quite unaffected, but all the adults that have emerged are dead. All the larvæ, save a few inactive, sickly-looking ones, are dead.

Eggs.—Numbers have hatched but there are no newly-hatched living larvæ to be seen.

The larvæ which hatched out in *P.* beaker of the first test (1 in 600) (Experiment No. XLIX.) and lived for eight days were put into *N.* pan of this series.

After 48 hours.

P.—10 more adults out. All the remaining pupæ and most of the active larvæ which were put in are dead.

Eggs.—The larvæ which have hatched out are now very numerous. A small proportion are dead, but most are quite active and many are in their second skins.

S.S.—9 more adults out. The greater number of the larvæ put in and a few pupæ are still living.

Eggs.—Swarms of active newly-hatched larvæ are visible.

N.—The flakes of naphthalene have now largely disappeared from the surface of the water; some have sunk, others have doubtless evaporated.

21 more adults are out—11 dead, 10 living. Only 3 living larvæ, of those originally put in and those transferred from the *P.* beakers in the first trial, remain.

Eggs.—Large numbers of dead newly-hatched larvæ are visible but no living ones.

Conclusion at 48 Hours.

Petroleum.—1 in 4,000 (1 cc. to 80 square inches area), while generally effective as a larvicide, allowed of a few survivors. It is very ineffective as against pupæ, a considerable proportion being able to complete their development and successfully emerge as adults. Its effect on submerged eggs or the larvæ hatching from them is negligible.

Soft Soap.—1 in 8,000 is practically useless. It kills only a small proportion of the active larvæ and pupæ and has no effect on the eggs or young larvæ that emerge from them.

Naphthalene.—1 in 8,000 is not effective as against pupæ, but (in a covered pan) kills all adults that emerged within 24 hours and about 50 per cent. of those emerging on the second day. With a few exceptions it is fatal to all larvæ, those emerging from eggs as well as those present from the start, for a period of 48 hours.

Experiment No. LI.

Sequel to Experiment No. L.

After 8 days.

P.—The few resistant larvæ of those put in continued to live, while the young larvæ that hatched from the eggs grew and thrived so far as a rather short allowance of food would allow them.

·5 gram of flake naphthalene was sprinkled over the surface of the water and the cheese cloth cover removed. Within 24 hours the great majority were either dead or dying.

A few survivors were still living after 48 hours, when a further gram of flake naphthalene was sprinkled on the water, the pan remaining uncovered.

Although the numbers living when this additional quantity of naphthalene was added were reduced a few of the larvæ survived and pupated.

S.S.—Upon the conclusion of the 48 hours' test there were a considerable number of pupæ and well grown larvæ present in addition to the swarms of young ones that had emerged from the eggs. Food (dead grasshoppers) was

placed in the tin and another ·5 gram of soft soap added, bringing soap content up to 1 in 4,000. This addition had no apparent effect in reducing the numbers after 48 hours; the young larvæ had grown and some of the older ones had pupated.

The addition of another gram brought the soap content up to 1 in 2,000. 72 hours later observation showed that the increase was partially effectual. Adults emerged from the pupæ and some of the better grown larvæ were still active, but the great proportion of the young larvæ were dead, although a few which had reached the third skin survived.

A third gram of soft soap was added (3 in 4,000). This also proved after 48 hours to be only partially effectual, living larvæ and pupæ being still present. 24 hours after the addition of a fourth gram (1 in 1,000 strength) all the survivors were dead. A fresh batch of larvæ and pupæ were added, and these also were all killed within 24 hours.

Of a further batch which were placed in the pan some survived until the second day, but all were dead after 72 hours.

Naphthalene.—In addition to the trial with the surviving larvæ of *P.*, in Experiment No. L., as above recounted, a few of the older larvæ which had survived the 48 hours' trial at 1 in 8,000 naphthalene were living, together with a number of young ones which had hatched out a day or two later when the effects of the naphthalene had passed off. A gram of naphthalene was sprinkled on the surface of the water to try the effect of 1 in 4,000 without the cover to the pan; most of the young larvæ were quickly killed off, but a few survived.

With a covered pan 1 in 4,000, however, proved effective, all the larvæ and pupæ or the adults emerging from them being killed.

Conclusion arising from the Sequel.

Soft Soap.—At less strength than 1 in a 1,000 soft soap is not an effective larvicide, but at this concentration it is decidedly superior to petroleum and is more lasting in its effects. Its effectiveness, however, gradually ebbs.

Naphthalene.—At 1 in 4,000 (1 gram to 80 square inches) kills all larvæ and pupæ or the adults emerging from pupæ in a pan with a cheese cloth cover. It is not, however, totally effective if the cover is removed.

Experiment No. LII.

Third Trial.

EFFECTIVENESS OF PETROLEUM AND SOFT SOAP, AND PETROLEUM, SOFT SOAP AND NAPHTHALENE IN EMULSIFIED FORM AS COMPARED WITH PETROLEUM ALONE TO DESTROY LARVÆ AND PUPÆ.

The emulsions used were constituted as follows:—*Petroleum and soft soap.* 3 parts soft soap melted by heat in 15 parts of water; 100 parts of petroleum added very gradually with much stirring and shaking while the soft soap was still hot.

Petroleum, Soft Soap and Naphthalene.—4 parts soft soap melted in 20 parts of water. 15 grams of naphthalene was gradually added to 100 cc. of petroleum (this appears to be the saturation limit at 80° F.). The petroleum with the naphthalene in solution was then added very gradually, with much stirring and shaking, to the hot soft soap solution.

In practice it was found best to dilute the small quantities of emulsions used with a little water before adding it to the pans which contained the larvæ and pupæ.

Tests.—These were conducted in cleaned empty petroleum tins cut down to six inches in depth; the surface area was approximately 80 square inches and the water contents 4,000 cc. Tins with cheese cloth covers.

Period 20 hours.

(1) *Petroleum.*—1 in 4,000 killed 7 pupæ and 37 larvæ. 1 pupa survived and an adult emerged but died.

P. S.S. emulsion.—1 in 8,000 killed all, 11 pupæ and 31 larvæ.

P., N. and S.S. emulsion.—1 in 8,000 killed all, 14 pupæ and 47 larvæ.

(2) *Petroleum.*—1 in 8,000.

After 20 hours 3 adults emerged and died, 5 pupæ and 3 larvæ living, 40 larvæ dead.

After 48 hours 3 more adults emerged, 1 living, 2 dead; 1 pupa living, 1 pupa and 3 larvæ dead.

P. S.S. emulsion.—1 in 16,000.

After 20 hours 1 adult emerged and died; 8 pupæ dead; 62 larvæ dead; 1 larva just capable of movement, but unable to leave the surface; was dead next morning.

P., N. and S.S. emulsion.– 1 in 16,000.

After 20 hours 10 pupæ dead; 36 larvæ dead; 1 larva just capable of movement, but unable to leave the surface; was dead next morning.

(3) *P. S.S. emulsion.*—1 in 20,000.

After 20 hours 23 pupæ dead; 27 larvæ dead; 3 pupæ and 5 larvæ swim freely; 2 larvæ make feeble movement, but cannot leave the surface.

After 40 hours 5 pupæ and 1 larva survive and are active.

P., N. and S.S. emulsion.—1 in 20,000.

After 20 hours 3 adults emerged and died; 20 pupæ and 29 larvæ dead; 1 pupa living; 4 larvæ make feeble movement, but cannot leave the surface.

After 40 hours all the survivors dead.

A second trial with *P., N. and S.S.* at 1 in 8,000 killed all the larvæ and pupæ put in the same day, and rendered a second batch put into the same tin on the following day incapable of active movement within one hour, but two or three of this second batch of larvæ survived until the next day.

Conclusion.

Petroleum, soft soap and naphthalene when blended together in emulsified form are much more effective and economical in use than when used separately.

P. and S.S. emulsion killed all at 1 in 16,000 and a large proportion at 1 in 20,000.

P., N. and S.S. emulsion killed all at 1 in 20,000.

Experiment No. LIII.

EFFECT OF PETROLEUM AND SOFT SOAP EMULSION ON THE EGGS OF *STEGOMYIA FASCIATA.*

This test was not carried out at the same time as the larval and pupal trials, but several months later.

Petroleum and soft soap emulsion used, 1 in 8,000 dilution.

Eggs laid not more than three weeks and dried about a week previously.

After 22 hours.

144 out of 156 eggs had hatched (= 92 per cent.), 2 larvæ showed feeble movement, and the rest were dead.

12 unhatched eggs transferred to tap water.

Transferred Eggs.—6 hatched next day, the larvæ lived.
Remaining eggs opened on the ninth day.
3 living larvæ and 2 dead ones extracted.
Remaining egg infertile.

Control.—A portion of the same batch of eggs, 196 in number, was placed in tap water.
81 hatched (= 41 per cent.), 1 larva died.

Recently-laid eggs that had been kept moist were also tested in a separate pan :—
36 out of 42 hatched in 22 hours (= 85 per cent.) and died.
6 unhatched eggs were transferred to tap water.
All 6 of the transferred eggs hatched next day ; the larvæ lived.

A batch of eggs that had been stored dry for 4 months was submerged in the same diluted emulsion, 1 in 8,000.

Out of 51 eggs, some of which showed signs of shrinkage, 6 hatched within 22 hours and 2 uncapped, but the still living larvæ had not emerged at the time of observation. The remaining eggs were removed to tap water. The larvæ which emerged in the emulsion all died.

After transference to Tap Water.

Next day 6 eggs uncapped :—2 larvæ out, making feeble movements.
2 ,, ,, , dead.
2 larvæ failed to get free of shells.

2nd day	2	hatched :—	1	dead,	1	living.
3rd ,,	5	,,	3	,,	2	,,
4th ,,	5	,,	4	,,	1	,,
5th ,,	4	,,	1	,,	3	,,
6th ,,	4	,,	All dead.			

On the 9th day the unhatched eggs were opened. 1 living larva was extracted ; all the other eggs contained either dead larvæ or were infertile.

Conclusion.

Submergence in petroleum-soft soap emulsion (1 in 8,000) is not effective in killing larvæ within the eggs, though it is possibly the cause of some mortality. It is, however, effective in that it induces a high percentage of the less resistant eggs to hatch at once, when the young larvæ are killed.

XI.—EFFECT OF SALT WATER (FROM FREETOWN HARBOUR) ON THE EGGS, LARVÆ AND PUPÆ OF *STEGOMYIA FASCIATA*.

In their conception these experiments were complementary to those performed by Macfie (1913–14) with common salt ("A Note on the action of Common Salt Water on the Larvæ *Stegomyia fasciata*," "Bulletin of Entomological Research," Vol. IV., Pt. 4, pages 339–344, by Dr. J. W. Scott Macfie, M.A., M.B., Ch.B., West African Medical Staff), their purpose being to test the effect of salt water on the eggs, a point Dr. Macfie did not deal with.

Experiment No. LIV.

EFFECT ON EGGS, LARVÆ AND PUPÆ CONTRASTED.

Preliminary.—A large batch of several hundred eggs laid two months previously was divided; half were put into water taken from the harbour and half into tap water.

A number of active larvæ and pupæ from the breeding pans were also put into the salt water. Temperature 80° F.

The first eggs to hatch were some of those in the salt water (within 15 minutes of immersion), those in the tap water commenced a few minutes later. None of the larvæ which hatched from the eggs placed in salt water survived more than an hour.

After 16 hours.—All the active larvæ placed in the salt water were dead. From the pupæ many adults had emerged and were living; the remaining pupæ were all living and successfully completed their development.

Eggs.—Two or three hundred had hatched, the number of larvæ which had emerged being larger in the salt than in the tap water. In the salt water all were dead, in the tap water all were living. After 48 hours a careful examination showed that of the eggs placed in salt water all had hatched save a few, which subsequent dissection showed contained dead larvæ.

Of the portion of the batch of eggs placed in tap water many were unhatched. Larvæ continued to hatch from the eggs at intervals.

Experiment No. LV.

TRIALS WITH EGGS ONLY.

Salt water from the harbour was filtered and 170 cc. placed into each of two beakers, *D* and *M*.

Controls.—170 cc. of tap water was placed in each of two beakers *Dc.* and *Mc.*

Eggs dry; laid on filter paper a month previously and stored dry. The slip of paper was divided and one portion with 102 eggs on it placed in *D.*, the other, with 106 eggs on it, placed in *Dc.*

Eggs kept moist; laid a month previously and stored under conditions which kept the filter paper on which they were laid moist.

The slip of paper was divided, a portion with 107 eggs on it was placed in *M* and the other with 95 on it was placed in *Mc.*

D. 102 dry.—After 2 hours' immersion 3 had hatched; larvæ dead.
„ 22 „ „ 89 „ „ ; „ „

Microscopic examination showed that 95 eggs had uncapped, but 2 larvæ died without emerging. Of the 7 remaining eggs 2 collapsed on drying, 5 retained their shape. These 5 eggs resisted continued immersion in tap water for 20 days, during which period they were subjected to "cooling" on five occasions. Dissection showed that 4 of the eggs contained fully developed larvæ, 2 of which were living, 1 showed no movement and 1 showed signs of decay.

Total hatched, 89 = 87 per cent.

Dc. Tap water control.—106 eggs (a portion of the dry batch used in *D*).
After 2 hours' immersion 33 had hatched and were living.
„ 22 „ „ 1 „ „ „ „ „

Microscopic examination showed that 34 eggs had uncapped. Of the 72 remaining eggs 2 had collapsed while immersed and 2 more collapsed on drying. 68 were re-immersed in tap water.

After 1 day	2	hatched.
„ 3 days	1	„
„ 4 „	1	„
„ 8 „	4	„
„ 9 „	11	„
„ 10 „	18	„
„ 11 „	4	„
„ 16 „	3	„
„ 18 „	2	„
	46	

50 per cent. of salt water was then added to the tap water in the pan.
The same day 1 hatched larva lived.
After 6 days 2 „ larvæ „
„ 18 „ 3 „ „ „

All the remaining eggs were dissected and 5 living larvæ were extracted, the remaining 11 eggs contained dead larvæ or were infertile. Total hatched, 81 per cent.

M. 107 *Moist.*—After 2 hours' immersion 49 had hatched—all dead.
„ 22 „ „ 46 „ „ „

Microscopic examination showed that 98 had uncapped; 3 larvæ had died without emerging. 5 eggs had collapsed while in the water, 1 collapsed on drying. 3 retained their shape.

These 4 eggs were then immersed in tap water.

After 1 day 1 hatched, and the larva lived.

„ 9 days 1 „ „ „ „ „

„ 10 „ 1 „ „ „ „ „

Dissection showed that the collapsed egg was infertile. Total hatched, 98 = 92 per cent.

Mc. Tap water Control.—95 eggs (a portion of the moist batch used in *M*).

After 2 hours' immersion 25 had hatched living.

„ 22 „ „ 2 „ „ „

Microscopic examination showed that 27 had uncapped, 8 eggs had collapsed while in water, 2 collapsed on drying, 58 retained their shape and were re-immersed in tap water.

After 1 day...	2	hatched	living.
„ 8 days	3	„	„
„ 9 „	2	„	„
„ 16 „	5	„	„
„ 17 „	2	„	„
	14		

100 per cent. of salt water was then added to the tap water in the pan.

The same day 1 hatched and died.

After 11 days 1 „ „ „

„ 12 „ 11 „ „ „

All the remaining eggs were dissected and found to contain dead larvæ or in a few instances were infertile. Total hatched, 54 = 57 per cent.

All the eggs were cooled on the 7th, 8th, 9th, 15th and 17th days after immersion.

Experiment No. LVI.

TRIALS WITH SPECIALLY RESISTANT EGGS

A large batch of eggs, which had been laid on filter paper and stored dry for two months, was immersed in tap water for five days. During this period several hundreds hatched. From among the resistant unhatched eggs two lots, each of 100 full eggs, were picked out with a wet camel hair brush and placed on wet filter paper. The slips of filter paper were allowed to dry and the collapsed eggs were removed, one of the slips was caught up by a draught during this operation and a number of eggs were lost.

There remained 65 full eggs on the one paper and 91 on the other.

The slip with 91 eggs on it was submerged in salt water, *S.IV.* That with 65 eggs on it was placed in tap water as a control.

S.IV.—After 20 hours 33 had hatched and died.

Tap Control.—After 20 hours 1 had hatched and was living.

After 44 hours' immersion no more larvæ had hatched. The slip was removed from the salt water and placed in tap water.

The record of the two lots is as under:—

RECORD OF THE EGGS AFTER REMOVAL FROM SALT WATER ON THE 4TH APRIL.

LOT.	DATE OF HATCHING.																
	APRIL.														MAY.		
	*10	*11	12	*13	14	15	16	*18	19	*20	*23	*25	28	30	4	10	12
S.W. ... ... (In tap water after 44 hours' immersion in salt water.)	3	1	31	...	...	...	...	...	...	...	...	...	1	...	1	1	1
Tap Water Control ...	6	6	..	18	1	2	2	3	2	3	4	7	...	2	1	...	1

On the dates marked with an asterisk the pans were cooled in an ice chest. During May the pans were placed out of doors at night; the 3rd and 9th were cool nights.

The larvæ of the *S.W.* lot which hatched out on the 4th and 10th of May died after emerging.

On the 13th May the remaining unhatched eggs were dissected. 9 living larvæ were extracted from the *S.W.* lot and 5 living larvæ from the control lot. The remaining eggs contained dead larvæ or were infertile.

SUMMARY OF RESULT.

Of 91 full resistant eggs 33 (= 36 per cent.) hatched in response to 20 hours' immersion in salt water (Harbour water), while only 1 (= 2 per cent.) of the 65 similar control eggs placed in tap water hatched during the same period.

Subsequently, of the balance of the 91 eggs, on removal after 44 hours' immersion in salt water to tap water, 39 (= 43 per cent.), hatched, all but two of the larvæ living, and 9 living larvæ were extracted from the eggs 39 days after their removal from salt water.

Mortality, 10 = 11 per cent.

Of the control eggs, 1 only had hatched during the first 44 hours' immersion. Subsequently, 58 (= 89 per cent.), hatched over a period of 39 days mainly in response to cooling, and 5 living larvæ were extracted from the egg.

Mortality, 1 = 1 per cent.

Conclusions.

The effectiveness of salt water as compared with fresh in causing eggs to hatch and killing the young larvæ is clearly demonstrated by these experiments.

The last experiment, dealing with resistant eggs, greatly modifies, however, one's views as to the practical usefulness of salt water as

an insecticide for the destruction of eggs. For it is evident that though it causes the immediate hatching and destruction of recently laid eggs, a considerable proportion of resistant eggs that have been dry for a long time are not affected within a period of 44 hours, and that the larvæ contained in such eggs are not killed.

For coast towns, however, salt water, if the expense of pumping were not too heavy, might serve as a very valuable flushing agent for gutters, sewers and cess pits after clearing. It would, I am informed, probably kill any *Ankylostome* eggs with which it came in contact, and if used for flushing drainage ditches in streets and watering roads, would, in addition to its services in reducing the numbers of mosquito and *Ankylostome* eggs effectually prevent the growth of weeds on road side spaces. In Freetown the clearing and weeding such spaces must be a considerable annual cost.

In the event of the use of salt water for such purposes, it should be applied lavishly, in the light of the foregoing experiments, at the *close of the rains* if its full effectiveness for the destruction of *Stegomyia* eggs is to be obtained, because a large proportion of the eggs laid in gutters and pools, in culverts, etc., will not attain their full powers of resistance (resting capabilities) until the establishment of the dry season has caused the evaporation of water in moist places and dried the eggs.

Experiment No. LVII.

TRIAL TO ASCERTAIN IF THE STIMULUS TO HATCH EXERTED BY SALT WATER ON THE EGGS OF *STEGOMYIA FASCIATA* IS DUE TO ITS SPECIFIC GRAVITY OR SOME OTHER CAUSE.

In the absence of other means the specific gravity of filtered sea water from the Harbour was tested with a urinometer and found to be 25°. Loaf sugar was then added to tap water until the solution showed the same specific gravity.

200 cc. of the salt water, 200 cc. of the sugar solution, and 200 cc. of the tap water were placed in respective beakers referred to as "Salt," "Sugar" and "Tap" in the following record.

Two batches of eggs were used: (1) laid on filter paper and stored *dry* for 3 months; (2) eggs that had been laid on filter paper about 3 weeks and had been kept *dry* for 10 days. A portion of both batches of eggs was placed in each of the three beakers. The temperature of the fluids just prior to the immersion of the eggs was 85° F.

The number of eggs put into the beakers was :—

"Salt,"	"Sugar,"	"Tap,"
20 recent.	28 recent.	20 recent.
291 old.	322 old.	324 old.
311	350	344

RESULT.

Lot.	Number of days after immersion that hatching occurred.											Result of dissection of unhatched eggs after 24 days' immersion.
	1	2	3	4	5	6	10	12	16	18	22	
"Salt,"												
Living ...	...	...	...	...	...	...	...	...	...	...	...	All the larvæ in unhatched eggs were dead.
Dead ...	155	19	65	9	1	...	...	...	...	1	...	
Total ...	155	19	65	9	1	...	...	...	...	1	...	250 out of 311. Mortality in egg stage, 19 per cent.
"Sugar."												
Living ...	16	52	184	17	1	...	1	...	...	...	...	All the larvæ in unhatched eggs were dead.
Dead ...	8	2	...	1	2	...	...	...	...	...	...	
Total ...	24	54	184	18	3	...	1	...	...	...	...	284 out of 350. Mortality in egg stage, 19 per cent
"Tap."												
Living ...	138	2	18	...	18	4	6	1	1	3	25	From unhatched eggs— Recent, 2 living larvæ extracted.
Dead ...	6	2	...	2	...	...	...	...	...	...	...	Old, 33 ,, ,, ,,
Total ...	144	4	18	2	18	4	6	1	1	3	25	266 hatched. 35 extracted. 301 out of 344. Mortality in egg stage, 12 per cent.

All the pans containing the eggs were cooled in the ice chest on the 5th, 6th, 10th, 16th and 22nd days.

This result suggests that the efficacy of salt water in inducing the eggs to hatch sooner than they would in fresh water is not merely a question of specific gravity; if reference be made to the tests of the effect of petroleum-soft soap emulsion, Experiment No. LIII. 1 in 8,000 dilution, on the eggs of *S. fasciata* (page 159), we find much the same phenomena occurring. It seems probable that the action is likely to be related to the penetrating properties of the fluids used, possibly the ease of absorption by the (colloid) substance of which the bosses are formed is the crucial factor.

Immersion in the salt and sugar solution seems to have been responsible for an increase of mortality to the eggs, apart from that to the larvæ after hatching, of from 12 per cent. to 19 per cent.—the numbers involved being too large to admit of the explanation of the 7 per cent. increase in both cases being due to chance.

XII.—NOTE RESPECTING THE SIZE OF MESH FOR NETTING REQUIRED FOR USE AGAINST *STEGOMYIA FASCIATA*.

The wire gauze used for the mosquito house had a mesh of 16 × 16 to the inch; for the cages 12 × 12 to the inch mesh was used; and for the tubes, used to test the length of life of the adults, the mesh was 14 × 14 to the inch. A supply of large and small mesh cotton netting was also required to be used for repairs, covers to breeding pans, temporary cages, sleeves, etc. No definite size of mesh had been specified. Of the two sizes received one had a mesh of 10 × 13 to the inch, and the other 11 × 15 to the inch.

During the progress of the research it was found that a few well-grown (medium to large-sized) specimens of *S. fasciata* and also a number of *S. sugens* escaped from large cages, where they were well fed, through the 12 × 12 inch mesh. From the tubes, where they were crowded, and, presumably, more anxious to escape, large sized specimens, which had only recently emerged, got out in considerable numbers through 14 × 14 to the inch mesh. In order to carry out the tests for which these tubes had been specially constructed, it was found necessary to remake them with 18 × 18 to the inch mesh.

With cotton netting it was found that the mosquitoes, bred in pans covered with that having the smaller sized mesh of 11 × 15 to the inch, easily got out, presumably shortly after emergence, before their wings and limbs were fully dry; while wild specimens gained entrance through the coarser netting, having 10 × 13 mesh to the inch, and oviposited in some of the experimental pans.

No instances of escape from the mosquito house through the 16 × 16 to the inch mesh were discovered, and, as the mosquitoes in it were reared from larvæ that had ample food supplies and consequently were large sized specimens, it is probable that few, if any, escaped. Even for small specimens escape would have been difficult, owing to the fact that large numbers of spiders, both within and without, spun webs and trailed their threads over the wire gauze, so that, had this been of an even larger mesh, it would soon have been rendered mosquito-tight.

In view of the fact that, under starved conditions, specimens of *S. fasciata* are reared of little more than half the size of the normal insects, the advice of the authorities concerned with the mosquito work in the Panama Canal zone* that a mesh not larger than 18 × 18 to the inch should be used in relation to Yellow Fever screening, is fully justified and cannot be too strongly urged upon our own authorities.

It may be of interest to record that I was unable to get from any of the stores in Freetown or from the Public Works Department, a supply of netting of less than 12 × 16 to the inch, though I was informed by one of the stores that complete made-up nets could be supplied in the smaller mesh.† Subsequently, the Hospital authorities found some spare 20 × 20 to the inch netting which they had in store.

If by any means traders could be induced to stock nothing of of coarser mesh than 18 × 18 to the inch, it would be to the general welfare of the inhabitants in situations where any danger of Yellow Fever epidemics exists. The supplying of larger mesh netting, even for the purpose of repairs, is to be deprecated.

* See "Monograph of the Mosquitoes of N. America, etc.," published by the Carnegie Institute, Vol. I., pages 363 and 364.

† Many of the nets I saw in actual use, including those at the Government rest house, were, however, of larger mesh.

XIII.—APPARATUS AND METHODS EMPLOYED.

Mosquito House. Plate 21, *page* 96.

This was designed by myself at the suggestion of Lt.-Col. Sir Ronald Ross. The woodwork was of unpainted teak, the stiffening framework of galvanized iron, and the wire gauze for the panels of phosphor-bronze. After eleven months' exposure to the weather at Freetown it was in perfect condition (*see* Figs. 21 and 22, pp 170 and 171).

Cages.

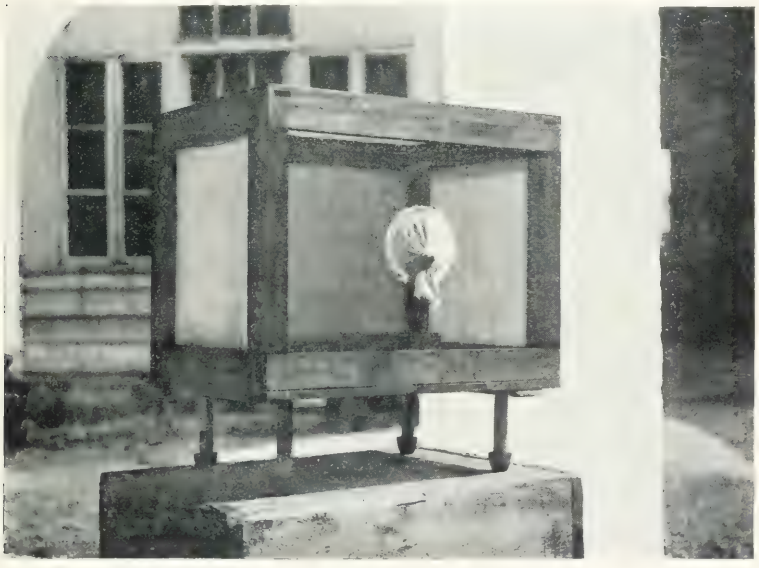


Plate No. 26.

A Mosquito Cage.

The floor boards were of teak with stiffening battens of galvanized iron, into which the legs screwed. The upper framework was of "flat oiled" pine. In the case of the cages intended for "infected" mosquitoes, the panels were of phosphor-bronze wire gauze. It was found convenient to cover this with thin cotton on the inner side.

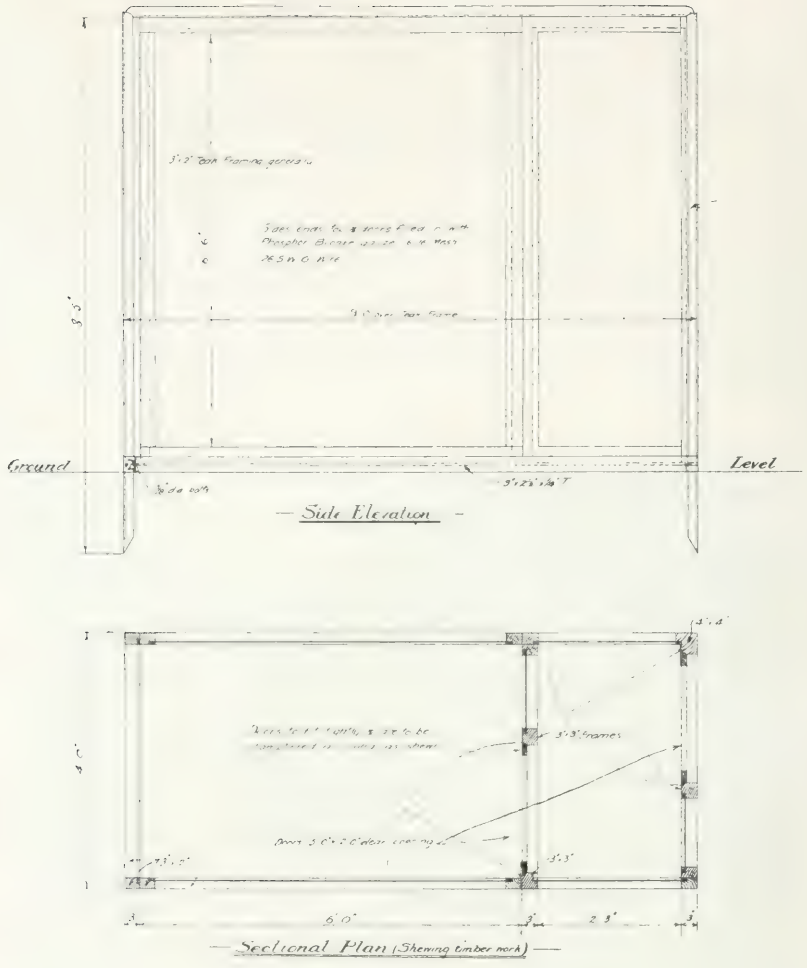
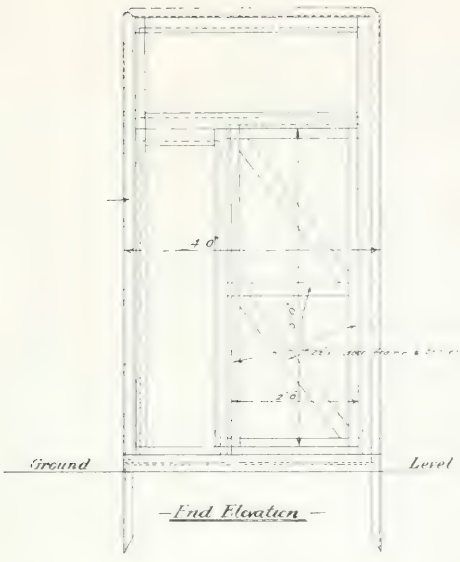
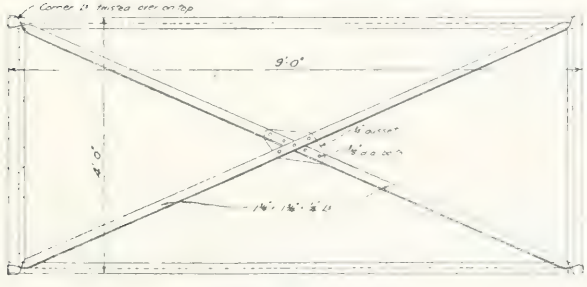


FIG 21. PLAN OF MOSQUITO HOUSE.



End Elevation

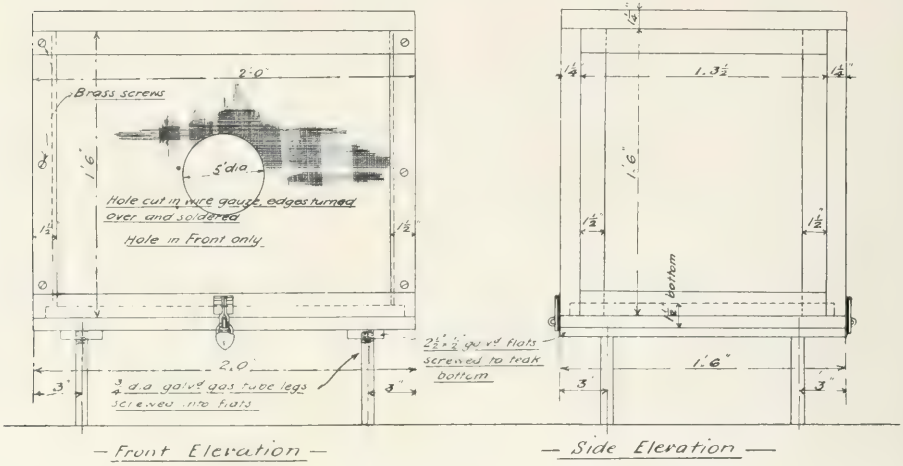
Plan on bottom (Showing steelwork)

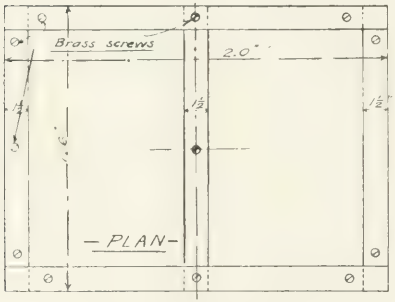


Plan on top

FIG. 22. PLAN OF MOSQUITO HOUSE.

For "uninfected" mosquitoes only the front panel, supporting the sleeve, was of wire gauze, the top and remaining sides being covered with cotton only. These cages, built to my own design, proved to be very serviceable and useful, and both in size and





Frames of 1½" × 1¼" Pine. Morticed, bottom edges grooved to fit on teak bottom.
Bottom of 1½" thick Teak. Rebated to take sides & ends.
Brass screws to be supplied for fitting together
Phosphor Bronze wire gauze covering 16·16 mesh, wire of 26 S.W.G., gauze to be fixed to inner side of frames by narrow battens, or metal bead & screwed down
Hasps, eylets & padlocks with 3 keys each, to be fitted back & front of the 3 covered cages only.

3 Cages to be covered.
3 Cages . . uncovered

FIG. 23. PLAN OF CAGE.

construction are suitable for a wide range of insect breeding. They can be taken down in a few minutes, and when packed flat take up a minimum of room, so that they can be easily transported.

Pens.

These were of phosphor-bronze wire gauze, supported on a light galvanized iron frame. Their use was to cover stored eggs, pans

of water containing larvæ, or tubes containing adults when it was desired to leave these exposed in the open air (*see* Fig. 24, page 174).

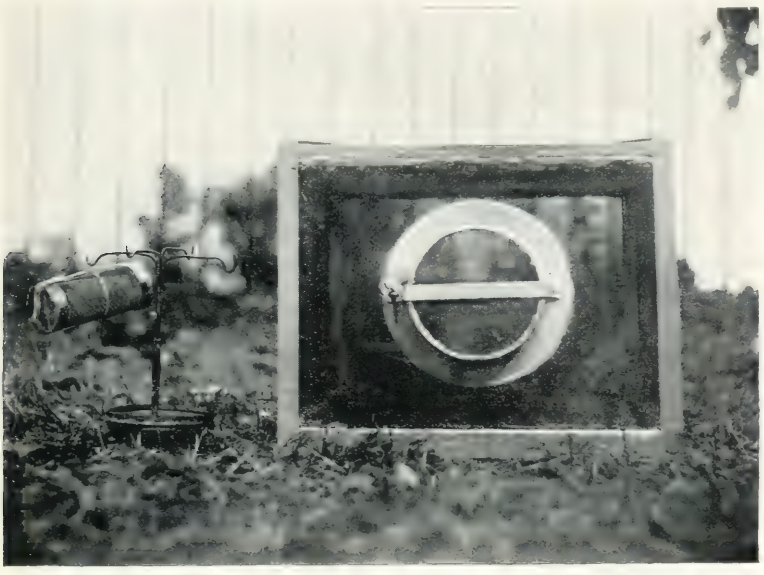


Plate No. 27.

Mosquito Pen and wire gauze tube for testing length of life of adults in various situations. Note method of suspension so as to isolate from ants.

Wire Gauze Tubes.

These were of wire gauze opening at either end (*see* Fig. 25, page 174); they were used to intern adult mosquitoes to test their length of life, and were also used to protect stored eggs from disturbance by small animals and the larger insects (*see* Plates Nos. 27 and 28).

Hurricane Lamp Chimneys.

These can be converted into useful little cages by covering the upper opening with fine gauze and putting the open end down on a pad of filter paper placed in a tin lid (*see* Plate No. 28, page 175).

Methods.

To obtain eggs.—The method mentioned by Christophers and Stephens (1908) of confining females in inverted screw-topped jars was found to answer well for single individuals. With *Stegomyia fasciata* and *S. sugens*, flooded blotting paper in the cover is sufficient to

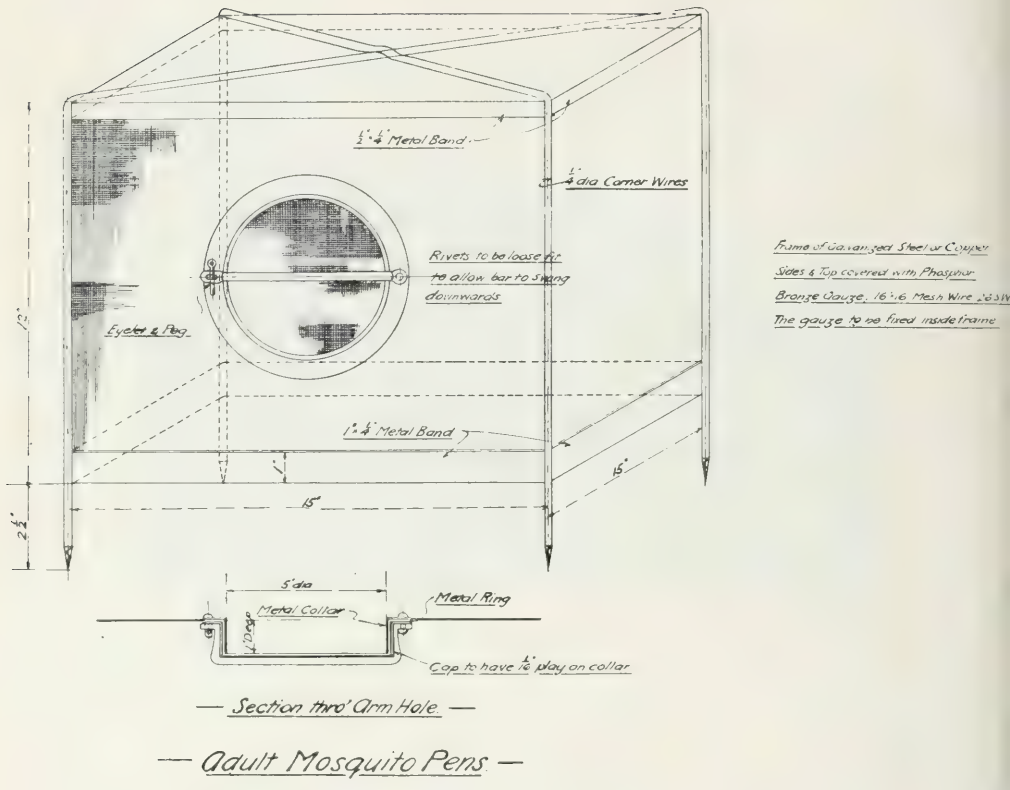

½"×¼" Metal Band
½" dia Corner Wires
Rivets to be loose fit to allow bar to swing downwards
Eyelet & Peg
Frame of Galvanized Steel or Copper
Sides & Top covered with Phosphor Bronze Gauge. 16"×16 Mesh Wire 26 SWG
The gauze to be fixed inside frame
1"×¼" Metal Band
12"
15"
15"
2½"
5" dia
Metal Collar
Metal Ring
1" Deep
Cap to have 1/16 play on collar
— Section thro' Arm Hole —
— Adult Mosquito Pens —

FIG. 24. PLAN OF PEN.

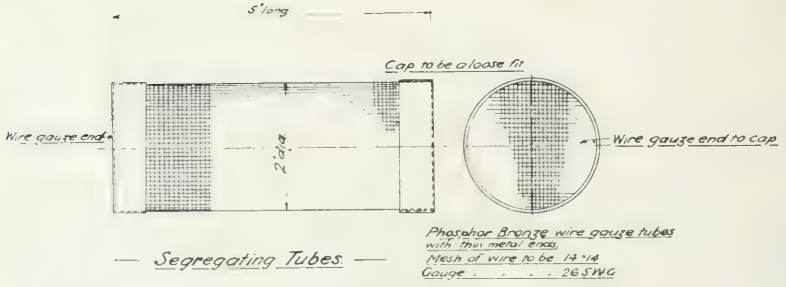

5" long
Cap to be a loose fit
Wire gauze end
2" dia
Wire gauze end to cap
— Segregating Tubes —
Phosphor Bronze wire gauze tubes with thin metal ends
Mesh of wire to be 14"×14
Gauge . . . . 26 SWG

FIG. 25. PLAN OF SEGREGATION TUBE.

induce oviposition, but unless the rim of the jar fits quite accurately minute house ants, belonging to the group *Leptothorax*, may gain entrance and kill the mosquitoes. If an accurate record of the number of eggs deposited is desired, care must be taken to search the rim of the jar just above its point of contact with the blotting paper, as eggs are frequently deposited or stranded in this position.

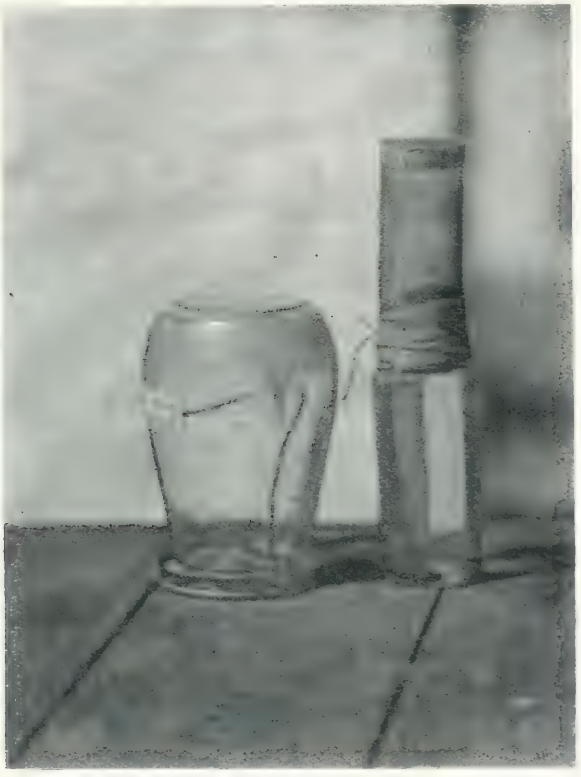


Fig. No. 28.

Small Cage made from a hurricane lamp chimney, also method of arranging wire gauze tube over jar containing pupæ in order to avoid waste of time in transferring adults.

For *Stegomyia simpsoni* and *S. luteocephala* some larger and more elaborate arrangement of a small pool was generally needed before the females could be induced to lay, and the latter species seems to greatly prefer ovipositing on or in close proximity to a surface of wet wood.

When eggs are required in numbers it is best to keep a number of mosquitoes of both sexes in a large cage. A convenient method of collecting the eggs of *Stegomyia* under these circumstances is to place a pan of water in the cage with slips of filter or blotting paper arranged so that one end dips into the water and the other is turned back over the edge of the pan; by adopting this method the eggs can easily be removed and counted without disturbing them. The water in the pans should be allowed to slowly evaporate, so that the eggs are left above water level, and do not hatch as would be the case if the pans were re-filled. If eggs laid on a wooden surface are required, the sides of a willow chip box answer excellently, as the wood is absorbent and of light colour, and its curvature is retained sufficiently to allow of its standing upright upon its edge in a shallow pan of water.

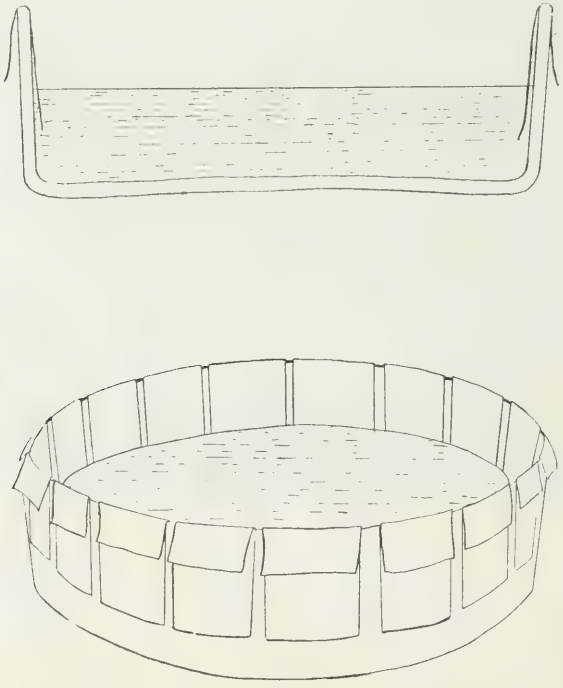


FIG. 26.

Hatching.—To test the hatching capacity of eggs laid by separate females or different batches of eggs laid by a single individual

requires daily observations, which may have to be continued for weeks together, and necessarily consume a great deal of time. If it is desired to submit the eggs to identical conditions the different batches will have to be kept separated from each other in the *same* pan of water. Two methods of fulfilling these conditions were employed. In the first the eggs were carefully submerged in small glass sporulating dishes, which were in their turn placed at the bottom of a large pan of water. It was found necessary to check the number of larvæ captured in the pan each day against the number of empty egg shells, and to do this the sporulating dishes had to be taken out of the pan for examination under a low-power microscope and replaced.

Plate No. 29.

Floating Docks. Method of testing the hatching of different batches of eggs under identical conditions.

Objections to this method were (1) that the eggs had to be completely submerged, and it has been stated, by Goeldi (see Carnegie Monograph, "Mosquitoes of North America," page 282), that continued submergence kills the eggs. Death rate from this cause is not by any means obvious in some of the experiments, but where *any* mortality at all has occurred, it is impossible to prove a negative. (2) Great care had to be taken in removing and

returning the small dishes to the large pan, in order to avoid scattering the eggs and mixing them. (3) The gradual accumulation of dirt and organic growth tended to obscure a free view of the eggs after two or three weeks' immersion.

An alternate method was devised of keeping the eggs in small floating docks (*see* Plate No. 29, page 177) with a fine gauze bottom made as follows. The top is taken out of the lid of a willow chip box, and the hoop is used to stretch a piece of motor veil (silk if possible) over the top of the box. Thread is wound round to prevent the box from coming to pieces when the water melts the glue with which it is fastened together. The bottom of the box is removed by soaking it in water, and three cork floats are pinned on to the sides at the level at which the dock is required to float.

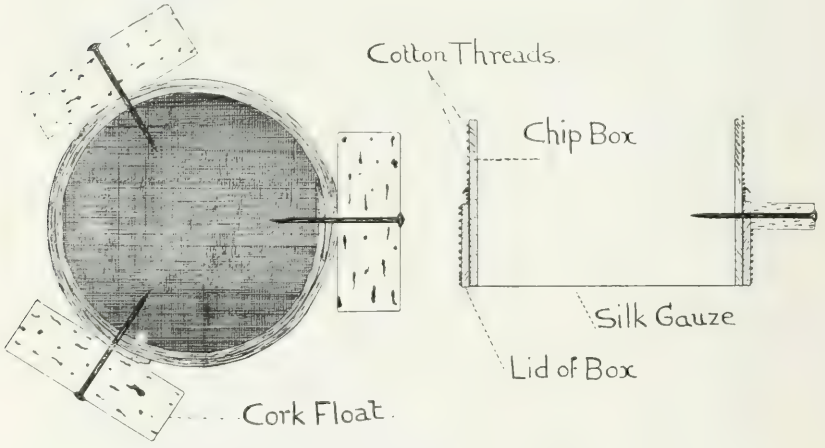


Fig. 27. Plan and Elevation of Floating Docks.

By adopting this plan examination is facilitated, the necessity of submerging the eggs is avoided, and a great saving of time is effected, as the sinking of floating eggs is a tedious process. Its defects are that with long continued use the gauze rots and the wood and cork become water-logged and lose their bouyancy. The saving of time is so great, however, that the plan is strongly to be recommended in all cases where it is not necessary to carry the hatching test to its ultimate conclusion of waiting until every single egg has had a complete chance of hatching. In most cases it is practical to close the experiment at a definite date and open the remaining eggs to see if they are dead or contain living larvæ.

Methods with larvæ.—For sorting out and transferring newly hatched larvæ a pipette with a rubber teat affords an obvious and speedy method. It may also be used for larger larvæ and pupæ, but care must be taken with the latter that the aperture is sufficiently large, otherwise they are easily injured.

When counting or catching newly hatched larvæ in a glass dish, the use of a black card or paper placed beneath it is helpful and, if the dish is supported above instead of resting *on* the black surface it renders observation still easier. With older larvæ, that have fed, a pale background is just as effective, owing to the dark colouration of the contents of the alimentary canal.

Larvæ and, to a less marked extent, pupæ of *Stegomyia* always avoid light; advantage may be taken of this when they are in a glass receptacle to make them collect in a corner or to one side for the purpose of rapid capture.

Breeding pans should not be placed in the sun or a strong light, otherwise they develop a growth of green algæ which appears to be detrimental, possibly by way of competition, to the development of the insects.*

If it is desired to breed *Stegomyia fasciata* free of gregarine parasites care must be taken to collect the eggs with a camelhair brush as soon after laying as possible and transfer them to clean filter paper. It is probable, if the sporocysts are voided by the females as suggested by Ross, that the young larvæ may ingest them at their first meal immediately after hatching.

Breeding pans in large cages containing a number of insects, especially when their numbers are recruited from several sources, are almost certain to become infected in a short time, and will remain permanently infected unless frequently cleaned.

For rearing the larvæ almost any sort of organic matter put into the breeding pans will serve, though care should be taken to thoroughly adjust the quantity to the size of the pan and numbers of the larvæ. Any sort of grain, dead insects, fæces of animals, fallen leaves, or other vegetable refuse, blood clots, etc., have all given good results.

Methods with adults.—To obtain a prompt supply of adults, dark coloured pupæ should be selected for preference, as the darkening signifies that the adult is nearly ready to emerge. To avoid waste of time in catching and boxing or caging mosquitoes for experiment, it pays to capture and segregate pupæ in jars of such size that an easy

* Experiments now in progress suggest another possibility, *i.e.*, that strong light or sunshine checks the growth of bacteria.

junction between the box or small cage and the rim of the jar with a slip of paper is possible (*see* Plate No. 28, page 175). One of the advantages obtained, apart from the saving of time, is that the age of the specimens is accurately known to within a few hours.

For infection experiments the clipping of one or both the wings is a reasonable precaution. To do this it is necessary to use chloroform ether or some other vapour to stupify the insects. Under cool conditions, temperature up to 65° F., ether causes a lower death rate than chloroform, but with a temperature of 80° F. chloroform answers best. After the operation it is well to place the insects in a warm incubator up to blood heat, or, failing this, in a strong draught, as this expedites their recovery and lowers the mortality resulting from the use of the vapour.

In dissecting infected mosquitoes which prove refractory to the usual methods of manipulation, a dissecting needle ground to a triangular section may be run up between the body wall and the internal organs from anus to head. Another needle is then drawn along one of the sharpened angles, thus slitting the insect longitudinally. With a little practice the gut and stomach of insects, which have recently gorged themselves with blood, may be extracted without rupture in this way. The method is also applicable and very useful when making dissections of any small grub like insect larvæ—one of its advantages being that the skin can be spread out flat and mounted independently so that its external surface with spines, setæ, tubercles and spiracular openings can be examined with care.

XIV.—SUMMARY.

MOSQUITOES AT FREETOWN.

I.—Introductory Notes.

Judged by sight or feeling mosquitoes are scarce in Freetown, and though a round with one of the Inspectors of the Sanitary Department may correct this view in so far as the larval stage is concerned, the increase in numbers of both larvæ and their breeding places *outside* the town area affords eloquent testimony to the efficiency of the Sanitary Administration.

Within the central area the larvæ of *Stegomyia fasciata* take precedence, followed by those of *Culiciomyia nebulosa*, which species appears a spasmodic breeder in comparison with the persistency of *S. fasciata*. *Culex decens* is also not uncommon. *S. simpsoni* breeds in water in the axils of the leaves of plants growing within the town, as do also *Uranotænia ornatus* and *Eretmopodites dracænæ*. *S. luteocephala*, *Ochlerotatus apicoannulatus*, *O. minutus*, *O. leucarthrius*, *Eretmopodites quinquevittatus* and *Culex nigripes* are also occasional breeders within the town area. Of the species of *Anopheles*, a few larvæ of (*Pyretophorus*) *costalis* only were taken in the town, but in the surrounding district this species breeds freely, being frequently present in rock pools with swarms of *S. sugens*. The breeding places of (*Myzomyia*) *funestus* are extensive areas of shallow trickling swamps lying east and west of the town.

II.—Bionomics of Stegomyia fasciata.

(A.) Eggs.

(*a.*) *Shape and structure.*—The dark spindle-shaped eggs of *S. fasciata* vary considerably in shape and size, affording specimens which approximate closely in general appearance to those of the allied *S. sugens*, *S. luteocephala* and *S. simpsoni*, all of which differ appreciably among themselves.

The bosses with which the eggs are studded are not mere structural excrescences of the shell, but are pockets containing small masses of a substance which, unlike chitin, is readily stained

by hæmatoxylin; these bosses are possibly connected with the ability which the eggs seem to possess of replacing moisture lost through desiccation.

(*b.*) *Laying.*—If actually laid on the water surface they are usually deposited so close to the margin as to become stranded by capillary action on the sides of the pools, or on partially submerged objects, such as dead leaves, lying in it. In many instances eggs were laid on wet surfaces quite beyond the limit of capillary action.

(*c.*) *Hatching and the conditions which control it. Experiments I. to XVIII.*—Incubation seems to invariably follow laying within 30 to 40 hours, at the Freetown temperature, but the hatching of any given batch may be distributed over a lengthy period. Apparently the eggs are endowed with a complex constitution, which allows of the whole of a batch hatching together, so soon as they are placed in water, or of a scattered emergence of the larvæ consistent with the view that some internal machinery which produces zonal or sectional hatching has been called into action. Experiment No. XVIII. suggests that the latency or activity of this machinery is determined by the conditions of humidity or drought which prevail *after* incubation. When a batch of dried eggs is placed in water a certain proportion generally hatch within a few minutes or hours, but others, apparently belonging to the same hatching zone, may resist the first or second immersion, yielding to some subsequent one. Similar powers of resistance will probably be shown by a proportion of the eggs in each hatching zone of a given batch.

After a series of experiments, Nos. IV. to XIII., in which various possible factors were tested, evidence was obtained that cooling to the extent of some 5° or 10° F. acted as a stimulus to induce the hatching of eggs that would otherwise have deferred doing so (Experiments Nos. XIV. to XVI.). A response to cooling accords well with the needs of the species, as a distributed emergence of larvæ so arranged allows of full advantage being taken of the increased facilities afforded for breeding in small and rapidly drying pools with the advent of rain.

Experiment No. XIX.—Agitation of the water, mentioned by Mitchell* as a factor in the hatching of eggs, failed to give any decisive result.

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* "Mosquito Life," page 26.

Bacterial action would appear also to be an important factor in hatching and in some instances to be essential (*see* footnote on page 51).

(*d.*) *Period of viability. Experiment No. XX.*—The period during which the eggs retain their viability would seem to be to some extent conditioned by temperature, humidity and ventilation, but, owing to the destruction of stored eggs by book-lice (*Psocidæ*) (Experiment No. XXII.), no adequate statistical evidence on this point was obtained. The longest period of viability was 262 days; in another test large numbers hatched after 200 days' dry storage. When kept continually immersed some eggs did not hatch for periods of from two to five months. (Experiments Nos. V., VI. and VII. show examples).

(*e.*) *Temperatures which the eggs are able to survive. Experiment No. XXI.*—Eggs brought back from Freetown and those laid in England hatched after exposure to 28° F. and 30° F. for 24 hours, but none hatched after an exposure of 25 days. 24 to 28 hours at 96° F. did not greatly, if at all, affect the percentage hatching at Freetown. In the experiment carried out at the Lister Institute there was a marked difference in the hatching percentage of Freetown eggs and those laid in London after exposure to 96° F. A few hatched after 24 hours' exposure to 102° F., but all the eggs of a batch placed at 108° F. for 24 hours failed.

(*f.*) *Enemies of eggs. Experiment No. XXII.*—The only active enemy discovered was a species of book-lice (*Psocidæ*) which wrought immense havoc among the stocks of stored eggs. Ants, considering the untiring activity of their search for the smallest particle of food, seemed strangely indifferent to the eggs.

(*B*) Larvæ and Pupæ.

The larval period is conditioned by temperature and food, breeding tests dealing with the latter factor only were practicable at Freetown, although some trials concerning the survival limits in regard to temperature were carried out.

(*a.*) *Experiments Nos. XXIII. to XXV.*—A very wide range of organic matter will serve as food for the larvæ of *S. fasciata*, and the water may be so heavily charged as to become foul and thick, without harming the larvæ, so long as it remains free of scum, floating oil or fat.

(*b.*) *Period of larval life.*—Under the most favourable circumstances the larval life is passed within four days ; on the other hand, with a scarcity of food, it is prolonged for upwards of 70 days. In tap water of average purity the larvæ are unable to pass the first moult apart from added nutriment, but they continue to mark time until the death of their fellows enables a few to complete their development. Probably, in an uncovered breeding pool the fall of organic dust would be sufficient to afford food for a fair number of larvæ.

(*c.*) *Small adults reared from starved larvæ.*—Shortage of food results in the production of small sized adults—a somewhat important point on the practical side. Well-covered cleanly cisterns therefore require covers of specially small mesh wire gauze (not less than 18 × 18), there being always a danger that eggs will be washed in from gutters during rain.

(*d.*) *Interaction between larval growth and the development of bacteria. Experiments Nos. XXVII. and XXVIII.*—Experiments show an apparent association between the speed of larval growth and the development of bacteria. The scarcity of bacteria in the gut of larvæ taken from water swarming with these organisms is probably evidence of the speed with which bacteria are assimilated, as it seems improbable that, by the use of the mouth brushes, or any other means, the larvæ could avoid swallowing them. The marked clearing action of mosquito larvæ in foul water affords a parallel instance of interaction between them and the bacteria, although this might be a secondary effect due to the absorption of organic matter by the larvæ, and not the ingestion of the bacteria. Experiment No. XXVIII. affords evidence of this interaction, and shows that, when two similarly stocked beakers were prepared, in one of which bacterial action was given four days' start of the larvæ, the bacteria absorbed nutriment, which, even in the event of the larvæ devouring them, could not be regained.

(*e.*) *Temperature which the larvæ and pupæ are able to survive. Experiment No. XXX.*—Larval growth and pupal development proceeded normally in a large tin exposed to full sunlight—the temperature of the water rising to 103° on one occasion. Trials with larvæ and pupæ taken from this tin showed that the upper limit of temperature they could survive lay between 112° F. and 115° F. As regards cold, pupæ reared at 80° F. remained active at 50° F., but about half the larvæ submitted to the test became stiff and immobile at this temperature, quite irrespective of size. With a further

reduction to 40° F. all the larvæ became immobile at the bottom, while the pupæ, with two exceptions, also lost all power of movement, but remained at the top. Both larvæ and pupæ recovered when the temperature was allowed to rise, but there was a mortality of 6 out of 40 larvæ and 2 out of 24 pupæ submitted to the test.

(*f.*) *Survival of larvæ and pupæ when submerged. Experiment No. XXIX.*—183 larvæ and 40 pupæ were submerged in a wire gauze tube of 18 × 18 mesh for 20 hours; 8 per cent. of the pupæ and 27 per cent. of the larvæ survived.

(*g.*) *Survival of larvæ on wet filter paper.*—Two larvæ in their fourth skins were stranded on a piece of filter paper which was kept continually wet; one lived 3 and the other 10 days.

(*h.*) *Enemies of the larvæ. Experiment No. XXXII.*—As pointed out by MacGregor,* the larger larvæ of *S. fasciata* apparently consume the smaller ones; mortality from this source seems to be limited to larvæ undergoing the first moult being ingested by those in their fourth instar. The habit of breeding in small collections of water, while saving the species from the attacks of many enemies, enhances the danger of fratricide, but the species is safeguarded from this risk to a considerable extent by the intermittent hatching of the eggs. Tadpoles, as stated by several authorities, certainly do not attack well-grown mosquito larvæ, though they probably have a checking influence, owing to competition for food. It seems possible, however, that the small larvæ undergoing their first moult, might be engulfed by tadpoles with other food. A small water-bug, found in rock pools, attacks the larvæ of *S. sugens*, and probably other species as well, but it was never seen in sufficient numbers to be a serious check. A species of *Ostracoda*, belonging to the genus *Cyprii*, seems to be inimical to mosquito larvæ, apparently as a competitor for food.

(*C.*) Adults.

(*a.*) *Pairing and feeding.*—In captivity there seems to be no regular precedence either of pairing or feeding; both functions are practised at any hour of the day or night—late afternoon being perhaps most favoured. The act of pairing commences during flight and occupies only a few moments, but is possibly repeated at frequent intervals. A single male is able to impregnate 10 females more or less effectually, and to fertilize 750 eggs (Experiments Nos. XLVI. and XLVII).

* "Journal of Tropical Medicine and Hygiene," No. 17, Vol. XVIII, 1st Sept., 1915, page 195.

(*b.*) *Development of eggs. On a single meal of blood and also on blood other than human.*—In feeding satiety is evidently aimed at, and an interrupted meal is completed as speedily as possible; a perspiring skin attracts more readily than a dry one. A single full meal of blood is sufficient for egg production in many cases, possibly for all, though the eggs are sometimes retained for many days. The blood of rats, dogs, goats and bandicoots seems just as effective for the development of the ovaries as human blood, but blood taken up from a living host seems to be a practical, though not a theoretical, necessity. *Fed on blood mixed with syrup. Experiments Nos. XLIV. and XLV.*—A single fertile egg was laid when the only food given was blood from a sheep mixed with syrup.

(*c.*) *Feeding in relation to egg laying.*—Females with ripe ovaries usually refuse to feed until they have deposited the bulk of their eggs, when they feed greedily. Females in their period of greatest vigour tend to develop and lay their eggs in masses at about three-day intervals, feeding on the first and second days after depositing their eggs, and fasting while the ovaries are full; Experiment No. IX. and the Appendix to Experiment No. XLVI. are typical instances. The female used in the latter experiment laid 837 eggs in twelve batches, exclusive of odd eggs, while the former, in 22 days, laid 712 eggs in fifteen batches.

(*d.*) *Retention of eggs.*—Fertilized females that have only received a single meal of blood may retain their eggs for a considerable period before laying them; Experiment Nos. XLI. and XLII. show examples.

(*e.*) *Choice of situation for depositing eggs.*—Tests showed that the widely-held opinion that the kitchen and boys' quarters are the most likely situations to look for *S. fasciata* was in the main correct, but it seems questionable if the preference is not as much due to the likelihood of there being foul water present, as to the chance of feeding on the boys. No eggs were ever deposited in a jar of clean water kept in the boys' bedroom.

In the mosquito house a wooden tub or tin pans were favoured as against a galvanized iron pail; Experiment No. XXXIII.

(*f.*) *Baits to attract pregnant females.*—Experiment No. XXXIV. affords evidence which seems fairly conclusive of some selection by the females, but it was by no means final, and is as suggestive of subordination to their own tastes as to the needs of their progeny.

(*g.*) *Eggs not laid apart from wet surfaces. Experiment No. XLIII.*—Fertilized females regularly fed on human blood would not oviposit when no wet surface or water was available.

(*h.*) *Length of adult life. Experiment Nos. XXXV. to XL.*—The longest lived specimen was the female used in Experiment No. IX., which was killed by ants after 95 days. The longest lived male life was 50 days, in Experiment No. XXXVII. Average lives of 29 days for males and 44 days for females are shown in Experiment No. XXXVIII., the specimens being fed on syrup and kept in a still and, for Freetown, not very moist atmosphere. Specimens kept in wire gauze tubes give very much lower averages, and no evidence was obtained that *S. fasciata* can habitually, or is likely, save under very exceptional circumstances, to tide over the dry season in the adult stage.

(*i.*) *Enemies in the adult stage. Experiment No. XLVIII.*—Owing to its retiring habits, *S. fasciata* probably suffers more from wingless than winged foes once it has gained entrance to a dwelling. Ants proved themselves to be deadly foes to caged mosquitoes; two species of spiders, one a small web spinner, the other larger, spinning no regular web, practically lived on *S. fasciata* in the mosquito house, and a small flattened scorpion was also discovered, which ate large numbers when confined in the same box with it. Young mantidæ were also found to capture and devour them. Ants, spiders and, perhaps, the scorpion are probably serious enemies even to active, unconfined specimens; the continual waving of the raised hind legs of the resting insects is, I suspect, a measure of preparedness to avoid attack by wingless foes.

A slender wall-haunting lizard quickly cleared a large cage of *S. fasciata* and probably acts as a salutary check to their increase.

III.—Parasites.

The only parasites encountered were a gregarine *Lankesteria culicis* Wenyon and a species of yeast.

IV.—Sterility of the Pupal Gut.

Experiments carried out in collaboration with Dr. G. G. Butler, although not conclusive, point to the probability of the sterility of the pupal gut, in so far as infection by bacteria is concerned.

V.—Notes relating to the Life History of some Related and Associated Species.

S. sugens.—The eggs are similar in structure and hatching habits to those of *S. fasciata*—cooling acting as a stimulus; larvæ are quite as rapid in development; pupation may occur within three days of hatching. The adults have many traits which suggest that their habits are more primitive than those of *S. fasciata*, which shows the characteristic laxness which seems so frequently to follow the close association of animals with man.

S. simpsoni.—Captive females fed heavily on human blood, but showed a decided preference for feeding at night. No pairings were seen, nor were any fertile eggs laid. The breeding of specimens from a collection of dry leaves taken in a water-hole proves that the species is able to resist drought, and is undoubtedly fitted to pass the dry season in the egg stage.

S. luteocephala.—The remarks made in reference to *S. simpsoni* are generally applicable to this species. Only infertile eggs were obtained, but the insects showed a decided preference for ovipositing on wood. The larvæ show some ability to survive among wet leaves.

Ochlerotatus apicoannulatus.—This species is also fitted to survive drought in the egg stage; the females bite readily and occasionally fill themselves with human blood. Pairing was never witnessed, nor were any eggs laid.

O. minutus.—Females of this species bit frequently and occasionally fed well on human blood. No eggs were obtained.

Uranotænia ornatus.—Reared from larvæ could not be induced to feed at all, and survived for less than two days.

Eretmopodites quinquevittatus.—The females of this and other species of the genus occasionally feed greedily on human blood. Pairing took place in a very small cage. The eggs are laid in twos and threes and vary greatly in size, being usually much larger than those of *Stegomyia*. Some cement appeared to be used to attach them just at or below water level. Fertile eggs failed to survive drying, but others of the same batch, which were kept in water, duly hatched. The larvæ are of the *Stegomyia* pattern, but are even more slender in build, and in habit are confirmed bottom feeders. The fourth skin larva retains the habit of browsing on the sides and bottom of the breeding pan that is characteristic of young larvæ of *S. fasciata*.

VI.—Eggs laid on fallen leaves in water-holes.

Eggs are laid on fallen leaves lying in water-holes. The following species were bred from leaves taken from an empty water-hole in January and immersed in March :—

233 specimens of *S. fasciata*; 24 of *S. simpsoni*; 81 of *S. luteocephala*, and 14 *Ochlerotatus apicoannulatus*.

VII.—Meteorological conditions as affecting breeding and distribution.

The early tornadoes which herald the breaking of the dry season begin as dry squalls with but little rain, and would afford an efficient means of bringing mosquitoes from the outlying districts into Freetown; this would apply especially to the *Anopheles* mosquitoes. At the onset of the rains breeding is necessarily restricted to a few pools in favourable situations; later these will be rendered untenable, but the insects reared in them will distribute and find other smaller and more numerous pools available as the showers increase in number and intensity. The small number of places available for early breeding should make it possible to schedule and treat them at short and regular intervals at the very commencement of the rains, even if outside the bounds of the regular sanitary district.

VIII.—Experiments dealing with the destruction of S. fasciata.
Experiments Nos. XLIX., LI., LII., LIII.

Naphthalene at 1 in 4,000, under the conditions of Experiment No. LI. is an effective larvicide; at 1 in 8,000 it is more effective than petroleum, but allows of a few survivors. Soft soap, at less strength than 1 in 1,000, is not an effective larvicide.

Emulsions of soft soap and petroleum are far more effective larvicides than either of them used separately, killing all larvæ and pupæ at 1 in 16,000 (water temperature about 80°, experimental pans covered with cheese cloth). With naphthalene added to the emulsion it was equally effective at 1 in 20,000.

As against submerged eggs petroleum and soft soap emulsion at 1 in 8,000 is not effective in killing the larvæ within the eggs. It has the result, however, of inducing a high percentage of the less resistant eggs to hatch at once, when the young larvæ are killed.

IX.—Effect of salt water on larvæ, pupæ and eggs of S. fasciata. Experiments Nos. LIV. to LVII.

Salt water (from Freetown Harbour) speedily kills the larvæ of *S. fasciata* but does not destroy the pupæ.

As against the eggs, though it does not destroy them, it causes a high percentage of the less resistant ones to hatch at once and a considerable percentage of the specially resistant. The young larvæ, after hatching, are speedily killed by it. The use of salt water for flushing culverts and gutters and watering roads might, if practicable, prove very beneficial. The effect of salt water as a stimulus to hatching appears to be unconnected with its specific gravity; a solution of sugar of the same specific gravity gave different results and both differed from the tap water control. Both solutions, however, were apparently responsible for a mortality of 7 per cent.

X.—Size of the Mesh of Netting for use against S. fasciata.

Adults can get through 10 × 13 cotton netting; they also pass 11 × 15 of the same material, and 14 × 14 wire gauze. No evidence of normal specimens escaping through 16 × 16 wire gauze occurred, but there is little doubt that the dwarf specimens caused by scarcity of food could do so. As suggested by the authorities of the Panama Canal Zone, for safety a mesh of not less than 18 × 18 should be used.

XI.—Methods and Apparatus.

This section deals with the apparatus used in this research, and the methods adopted in carrying out breeding and other experiments.

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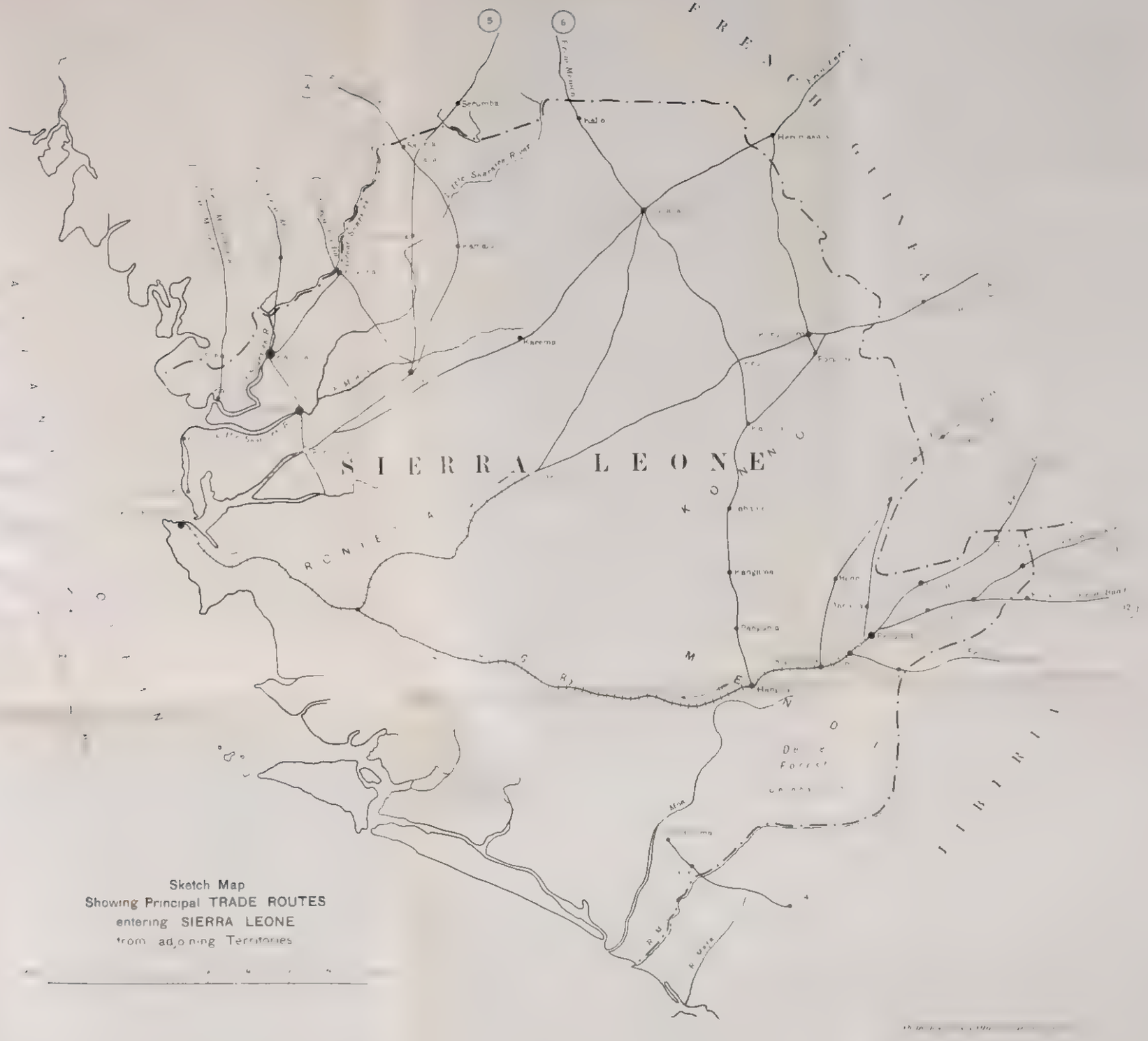

Sketch Map
Showing Principal TRADE ROUTES
entering SIERRA LEONE
from adjoining Territories

YELLOW FEVER COMMISSION (WEST AFRICA).

CORRESPONDENCE RELATING TO THE POSSIBILITY OF THE INTRODUCTION OF YELLOW FEVER BY LAND INTO SIERRA LEONE.

At an early stage in this enquiry the Yellow Fever (West Africa) Commission thought it desirable to obtain some information in regard to the possibility of the introduction of Yellow Fever in the ordinary course of overland trade between Sierra Leone and the neighbouring Dependencies. The following was received in reply :—

SIERRA LEONE.

THE GOVERNOR TO THE SECRETARY OF STATE.

(Received 28th July, 1913.)

Government House, Sierra Leone,
16th July, 1913.

SIR,

In accordance with your instructions, I have the honour to transmit a report on the chief land routes for traffic coming into Sierra Leone from the surrounding French and Liberian territories, accompanied by a sketch map.

I may mention that the report and sketch map have been compiled by the Officer Commanding the Sierra Leone Battalion, West African Frontier Force,* from the several reports and sketch maps furnished by the District Commissioners in the Protectorate.

I have, &c.,

E. M. MEREWETHER,
Governor.

* The late Major (temporary Lieutenant-Colonel) G. P. Newstead, Suffolk Regiment.

[*Enclosure.*]

Report on Principal Trade Routes coming into Sierra Leone from French Guinea and Liberia adjoining.

The routes are numbered from West to East from 1 to 12, corresponding with those shown on the accompanying sketch map.

No. 1. From Maurikania and Mellakori. Enters the Protectorate at Mislaia, thence to Kaseri, by canoe to Balu, by road to Yongre, and thence by canoe to Freetown.

Trade chiefly cattle for cash and rice.

No. 2. From Massaia and Mola.—Through Kambia, Mange, Port Lokko and Magbile into the Ronietta District.

Trade chiefly cattle for cash.

No. 3. From Kindia.—Enters the Protectorate at Kukuna and passes thence

(*a*) to Batkanu ;
(*b*) to Kambia, Mange, and Port Lokko ;
(*c*) to Mabanta and Port Lokko.

Trade chiefly cattle for kola nuts.

No. 4. From Medina.—Enters the Protectorate at Saionia and follows road to Batkanu *viâ* Yana and passes through

(*a*) Samaya and Laminaya ;
(*b*) Samaya, Sassa, and Wonkifu ;
(*c*) Kamakuia and Kamalu.

A considerable trade is done on these routes in cattle for kola nuts.

No. 5. From Serumba.—Direct to Yana and thence through Kamalu to Batkanu.

Trade as in Numbers 3 and 4.

No. 6. From Mamon.—Through Kalia to Kaballa and thence

(*a*) through Karema to Port Lokko. This is the direct road, good road, and much used ;
(*b*) through Mabonto to Boia Extension Railhead. Much used ;
(*c*) through Kruto and Kayima to the Mendi country and large towns on the Eastern Section of the Railway.

Trade chiefly cattle and other produce.

No. 7. From Farana.—Enters the Protectorate near Heremakona and proceeds thence to

(*a*) Kaballa and on to Port Lokko as in 6 (*a*);

(*b*) Kaballa and on to Boia Extension Railhead as in 6 (*b*);

(*c*) Krubum and Kayima, thence to Mendi country as in 6 (*c*).

Farana is a large administrative post. The road from here to Kaballa is kept well open and much trade passes.

No. 8. From Sarafinian. Passes to Krubum and thence to Boia Extension Railhead *viâ* Kruto.

This road is difficult and hilly in places and is not extensively used.

No. 9. From French Kissi.—Enters the Protectorate at Kamiendo and passes through Loma to the Railway at

(*a*) Segbwema *viâ* Bendu;

(*b*) Pendembu *viâ* Komatendu.

There is also a subsidiary road from Korumba joining at Manawa.

No. 10. From Gekedu (French Kissi).—Crosses the Moa River into the Protectorate near Turadu and passes *viâ* Kailahun to Pendembu and Baiima. Largely used by the Upper Kissi, Sangaras, &c. from French Guinea.

Trade chiefly cattle and produce for cash, goods and utensils.

No. 11. From Lankorri Districts (Liberian).—Enters the Protectorate through Dambarra and passes thence *viâ* Dodo and Giema to Pendembu.

The trade consists of palm kernels, &c., for cloths and goods.

No. 12. From Bandi country.—Through Kolahun and Foya (Liberia). Strikes the main road through Dodo and Giema to Pendembu and Baiima. Extensively used.

Trade chiefly produce for goods.

No. 13. From South of the Mauwa River (Liberia).—Enters through Kebawana (Liberian Customs station) and passes through Barriwalla to Baiima.

Trade as in No. 12.

No. 14. From Barclay Gene to British Gene. The country between routes 13 and 14 consists chiefly of dense forest-clad hills, practically uninhabited, and there are no routes carrying any considerable traffic.

South of route No. 14 the trade with Liberia would appear to be carried chiefly by sea.

YELLOW FEVER COMMISSION (WEST AFRICA).

CORRESPONDENCE RELATING TO THE POSSIBILITY OF THE INTRODUCTION OF YELLOW FEVER BY LAND INTO THE GOLD COAST.

At an early stage in this enquiry the Yellow Fever (West Africa) Commission thought it desirable to obtain some information in regard to the possibility of the introduction of Yellow Fever in the ordinary course of overland trade between the Gold Coast and the neighbouring Dependencies. The following were received in reply :—

GOLD COAST.

THE GOVERNOR TO THE SECRETARY OF STATE.

(Received 11th May, 1914.)

Government House, Accra,
23rd April, 1914.

SIR,

I have the honour to forward herewith, for your information, a tabulated statement in which is embodied all the information at my disposal on the subject of trade routes leading into this Colony, and two copies of the $\frac{1}{1,000,000}$ map*, on which the routes in question are marked. The numbers given in the final column of the tabulated statement correspond with the numbers marked against the trade routes shown on the map.

Similar information with regard to the trade routes leading into Ashanti and the Northern Territories is being collected, and will be forwarded to you as soon as it is received.

I have, &c.,

HUGH CLIFFORD,
Governor.

* Map A of the Gold Coast, &c.

MAP A.

Geographical Section General Staff, 1906

War Office Office, London

MAP
OF THE
GOLD COAST, ASHANTI,
AND
NORTHERN TERRITORIES.
Illustrating despatch from the Governor of the Gold Coast 23rd April 1914, included in Vol. III. inventory
REFERENCE
Railways completed & open
Railways under construction
Roads
Boundaries
Scale 1 inch to 8 miles or 1 inch to 16 Miles
Compiled in the Topographical Section General Staff
Topographical Section General Staff No. 2564
War Office July 1911

[*Enclosure.*]

Trade Routes Leading into the Gold Coast Colony.

Point of Entry.	From / To.	To / From.	Route	Volume.	Season.	Trade, 1913.
1	Moshi Country and Basin of Niger	↓ ↓	Bawku, Gambaga, Karaga	Large ...	Dry ...	*Imports* :—Value £37,093. Principally cattle, sheep, horses, donkeys and country cloths and a little hardware, cotton, palm oil and native foodstuffs. *Exports* :—Kola, 117,990 lbs.; salt, 560 lbs.; figures for other exports not available. *Above combined with* 2.
		(*a*) Kintampo and Coomassie	Tamale, Yapei			
		(*b*) Coomassie and Cocoa District	Kpabia, Salaga			
2	Lome ...	Bawku ...	By rail to Agome, thence to Sansanne Mungu	Not large ...	Dry ...	*Combined with* 1.
3	Lome ...	Locally in N.T.	By rail to Agome, thence to Yendi	Small ...	Dry ...	*Value of imports* :—£706. Principally cloth and beads. *Exports* :—Negligible. Kola and salt.
4	North of Togoland	Coomassie ...	Yendi, Sambu, Kpabia, Salaga	Large ...	Dry ... Dec.—Apr. Apr.—Aug.	*Imports* :—Value £1,399. Principally sheep, goats, shea butter and leather goods. *Exports* :—Kola, 671,310 lbs.; salt, 16,180 lbs.; other exports trifling.
5	Yendi ...	Locally in N.T.	Kadenge ...	Small ...	Dry ...	*Imports* :—Value £847. Principally cloth and native produce. *Exports* :—Kola, 17,330 lbs.; salt, 1,064 lbs.; other exports trifling.

Point of Entry.	From / To	To / From	Route.	Volume.	Season.	Trade 1913.
6	Salaga and North	(*a*) Agome and Lome	Krupe ...	Large	Perennial...	*Imports* :—Value £1,674. Principally cotton and hardware.
		(*b*) Dodowa, Accra, Krobo Mts.	Krupi, Pajai, Krachi, Kpong		June & Dec. quarters	*Exports* :—2,038 cattle, 1,766 sheep. 2,218 cattle and 1,477 sheep passed southwards at Darcar Mouth.
7	Ashanti ...	(*a*) Agome and Togoland	British Kratchi	Entered 9,193, left 10,257 persons	Regular . .	*Imports* : Value £401. Principally beads and cotton.
						Exports :—Ivory, 1,436 lbs. ; kola, 3,823 lbs. ; rubber, 2,375 lbs. ; salt, 30,050 lbs.
	Northern Togoland	(*b*) Kwahu ...	British Kratchi		—	For work on cocoa farms.
8	Togoland ...	Kwahu ...	Nkami ...	Entered 3,101, left 3,967 persons	Highest Jan. to Mar. and Sept.	Trade negligible.
9	Kwahu ...	(*a*) ?	Pesse	Entered 5,558, left 5,990 persons	Highest May to July	*At Br. Kpeve.*
	Ho and Pando Districts, Togoland	(*b*) Alternative route to (10), not much used				*Imports* :—£2,082. Principally cattle, sheep and goats.
						Exports :—£10,075. Principally wearing apparel and specie.
10	Togoland and French Territory	Cocoa and Coast Towns	Frankadua to Senkye or Akuse	At *Senkye* :—Entered 43,527, left 29,804 persons	Highest Oct. and Nov.	*At Senkye.*
						Imports.—11,196 cattle, 16,807 sheep and goats.
					Jan. to Mar.	*At Frankadua.*
						Imports :—Value £21,074. Principally sheep and goats.
						Exports :—Value £44,223. Principally specie and wearing apparel.

11	Togoland ...	Cocoa and Coast Towns	Abutia and Adidome	Small ...	Perennial ...	Native cloths and sheep; trifling; local.
12	Togoland ...	Cocoa and Coast Towns	Avege and Adidome	Small ...	Perennial ...	Goats, fowls and sometimes cattle; trifling; local.
13	Togoland ...	Cocoa and Coast Towns	Kpeve and Adidome	—	Perennial ...	*Imports*:—Value £2,403. Principally foodstuffs and mats. *Exports*:—Value £1,646. Principally dried fish.
14	Togoland ...	Cocoa and Coast Towns	Deodze, Dabala, Teji	—	Perennial ...	*Imports*:—Value £3,211. Principally sheep, goats and general goods. *Exports*: Value £4,689. Principally dried fish.
15	Lome ...	Cocoa and Coast Towns	Kwitta by land to Attititi by land or Kwitta Lagoon	—	Perennial ...	*Imports*:—Value £18,539. General goods. *Exports*:—Value £16,115. Principally dried fish.
16	Assinie ...	Half Assinie ...	Beach ...	Principal route	Perennial ...	*Imports*:—Large in dried fish; also beads, pomades and cloths. *Exports*:—Rubber.
17	Assinie ... Aboisso ...	(*a*) Half Assinie (*b*) Half Assinie	Lagoons ..	Principal route	Perennial ...	(*a*) as 16. (*b*) Cloths, pomades, perfumes.
18	Dissou ...	(*a*) Jena .. (*b*) Boinso ...	*viâ* B.P. 52 ... *viâ* B.P. 51.	Small ...	Perennial ...	Seldom used except by timber cutters.
18	Aboisso ...	(*c*) Sanom ...	Ebakro ...	Infinitesimal	Perennial ...	Petty in perfumes, cloths, haberdashery. Almost solely confined to natives of the Colony, who go to Aboisso to purchase goods for retail locally.
19	Aboisso ...	Anchi ...	Dibi-Yakase ...	Infinitesimal	Perennial ...	
20	Aboisso ...	(*a*) Kobina Krom (*b*) Amoya ... (*c*) Krokosua ...	Akeykro and Dadiaso ? ?	Infinitesimal	Perennial ...	
21	Aboisso ...	Debiso ...	?	Infinitesimal	Perennial ...	

THE GOVERNOR TO THE SECRETARY OF STATE.

(Received 28th December, 1914.)

Government House, Accra,
5th December, 1914.

SIR,

I have the honour to forward herewith, reports from the Chief Commissioner of Ashanti and the Chief Commissioner of the Northern Territories, relating to the trade routes leading into those Dependencies, together with tabulated statements in duplicate, in which is embodied all the information at my disposal on the subject. I also enclose one copy of the $\frac{1}{1,000,000}$ map,* on which the routes in question have been marked. The numbers given in the first column of the statements correspond with the numbers marked against the trade routes shown on the map.

I have, &c.,
HUGH CLIFFORD,
Governor.

[*Enclosure* 1.]

Chief Commissioner's Office, Coomassie, Ashanti,
5th October, 1914.

SIR,

In reply to your letter of the 16th June last, I have the honour to forward a report on the principal trade-routes into Ashanti.

I have, &c.,
F. C. FULLER,
Chief Commissioner, Ashanti.

REPORT ON PRINCIPAL TRADE ROUTES COMING INTO ASHANTI.

On the western frontier of the Northern Province of Ashanti there appear to be no defined routes.

There are numerous small paths crossing the frontier. The trade consists of farm produce grown in Banda territory.

In the Western Province there are three main routes :—

No. 1 *W.*, through Bonduku from Kong and Haut Senegal et Niger, enters near Sikasiko. Trade : chiefly cattle, hide and kola, and some native cloths.

No. 2 *W.*, a continuation of route No. 1 W. from Bonduku, enters Ashanti near Goresua and joins No 1. (branch 3) at Pulliano. Trade : cattle and rubber.

* Map B of the Gold Coast, etc.

MAP B.

War Office July 1911

MAP
OF THE
GOLD COAST, ASHANTI,
— AND —
NORTHERN TERRITORIES.
Illustrating despatch from the Governor of the Gold Coast 5th December 1914 included in Vol III Investiga Report Yellow Fever West Africa Commission
REFERENCE
Railways completed & open
Railways in progress
Scale 1 inch or 1.014 Inches to 16 Miles
Miles
Kilometres
Compiled in the Topographical Section General Staff
Topographical Section General Staff No 2564
War Office July 1911

No. 3 *W.*, from the southern and central portions of Ivory Coast, enters near Pamo, thence to Berekum, where it joins route 1 (branch 2). Trade: rubber.

The last two routes are little used since the fall in price of rubber. When the Bibiani Goldfields were working there was another route from Pulliano, through Pamo and Kukuom and Bibianaha; should they re-open this route would become important.

In addition, there are numerous small paths between villages.

FROM TOGOLAND.

There are no trade routes from the above territory; small local traffic exists between villages across the river.

All the remaining trade roads lead to and come from the Northern Territories, which Dependency will, no doubt, furnish a separate report.

[*Enclosure* 2.]

Chief Commissioner's Office, Tamale,
28th September, 1914.

I have the honour to transmit, under separate cover, a map with the principal trade routes entering this Protectorate from the surrounding foreign territories shown thereon.

I transmit, herewith, a report on these trade routes tabulated as requested. The routes, as will be seen, are somewhat complicated, for the main roads throw off many branches, which sometimes join other main routes. These are evidently used to avoid congestion in the cattle traffic, and, at certain times of year, to obtain better pasturage and water than are to be found on the main routes.

While recognizing that the use of so many roads by traders entering the Northern Territories increases considerably the chances of infection and the spread of disease, it appears to me that, until the Government is prepared to provide, at the various halting places, adequate water and possibly food supplies, for the use of traders and live stock passing up and down the country, it cannot well restrict them to the use of certain routes—a course which would minimize the risk of infection of local natives and of their cattle.

It may be of interest to record my experience that the mosquitoes *Stegomyia fasciata* and *Anopheles costalis* are to be found throughout the Protectorate.

During my recent tour I caught specimens of both at Lorha, and during this month in my house at Tamale. The "tsetse" fly is found everywhere in the vicinity of the large rivers.

I attach for convenience an extract—"Imports and Exports"—from my Annual Report on this Protectorate for 1913,* to be read with the report on trade routes.

C. H. ARMITAGE,
Chief Commissioner, Northern Territories.

IMPORTS AND EXPORTS.

As stated in previous reports on this Dependency, it is impossible, under present conditions, to give more than an approximate estimate of the volume of trade entering and leaving the country. Trade statistics are kept at stations situated on the main trade routes, but, as the registration of live stock and trade goods is voluntary, and as many caravans, especially those composed of live stock, pass through the stations during the night, the figures given can be looked on only as an indication of a general increase or decrease in trade, as the case may be. The trade route from the north through Daboya to Kintampo, and others of minor importance, do not pass through any stations where statistics can be collected, nor are such compiled at Kintampo in Ashanti. Imports consist generally of cotton and woollen goods, silk handkerchiefs and lengths, hardware, haberdashery, beads, brass rods, tobacco, tinned provisions, and kola nuts from Ashanti.

With the exception of the North-Western Province, where a distinct decrease in the caravan trade in cattle and moshi cloth is reported, the import and export trade has increased greatly during the year under review; and it may be noted that the falling off in the North-Western Province is more than compensated for by the largely increased volume of trade that passes through the North-Eastern Province, particulars of which will be given later. This increase is directly due to the subjugation in 1911 of the wild tribes which held the Tong Hills as their stronghold and terrorised the surrounding country.

A broad road now runs through Tinzugu and Winduri in the heart of the Tong Hills, and this route is becoming most popular with the French traders.

The figures available show a total of 310,699 loads registered during the year, as against 229,750⅛ registered in 1912: an increase of 80,948½ loads. The principal increases appear under the following heads:—

Cattle 40,346, sheep 40,345, donkeys 9,087, shea-butter 5,855½, dawa-dawa 2,128, and native blankets 1,837, while

* [Cd. 7050/47], 19th August, 1914.

decreases occur under "miscellaneous" 17,938½, cloth 8,886½, donkey loads (miscellaneous) 7,810, and donkey loads (shea-butter) 1,856.

The large increases in live stock are due to the failure of the crops and to lack of water in the area of Upper Senegal lying between Wagadugu and Timbuctoo, but, when the railway line now in course of construction from Dakar taps that country, we must expect a diversion of the trade, and a heavy fall in the number of animals passing through this Dependency to Ashanti and the Colony. In view of the fact that no transport facilities, beyond the excellent main roads, are available for the natives, and that no provision for such is contemplated, it is encouraging to note the increase under the heads of "shea-butter," "dawa-dawa," and "native blankets," for it demonstrates that the natives are realizing that money is to be made by the exploitation of these local industries.

In referring in my Annual Report for 1912 to alleged decrease of 24,188 loads under the heading "donkey loads, miscellaneous" as compared with the figures recorded under that head for 1911, I wrote as follows :—

> "I believe that donkey transport is, if anything, on the increase, and that the figures available are quite misleading. These are only quoted for comparison with those contained in the Annual Report on Ashanti."

These remarks apply equally this year.

During the year kola nuts and salt were exported over the inland frontiers through the southern preventive stations established on the eastern boundary of the Dependency as follows :—

Destination.	Kola (lbs.)	Salt (loads).
British	594,180	56
French	219,691	560
German	150,086	17,668
Total	963,957	18,284

The above figures were supplied by officers of the Preventive Service.

Fish, caught in the Volta River and sun dried, are exported to Ashanti and the coast, but this industry is in the hands of the

Bator tribe, who come up the river and encamp on its banks during the fishing season.

The Commissioner of the Southern Province reports as follows :—

"From the trade statistics furnished by the Commissioners there appears to be a considerable increase in the number of cattle, sheep and donkeys passing south to Ashanti.

"The District Commissioner, Salaga, reports that there has been a considerable drop in the number of loads of kola nuts, which he considers is due to the large quantities that are now being shipped by sea to Southern Nigeria. There has been a very slight increase in the kola trade passing through Tamale, whilst the returns from Bole show that the kola trade has been much the same as the previous year.

"There is a steady rise throughout the Province in the export of shea-butter and also in dawa-dawa. There is also throughout the Province a large increase in the number of loads of salt passing through.

"With regard to the imports of cloth from the Colony and Ashanti, there has been an increase, as also in loads of miscellaneous goods, with the exception of Salaga.

"There has been a decrease in goods imported from Togoland. The turnover in Messrs. Paul Hutter and Company's store at Tamale shows a decrease of £284 11s. 2½d. compared with 1912. The clerk in charge of the store is unable to furnish me with an explanation as to this decrease.

"Tamale port continues to increase in importance; several new compounds have been built during the year, and applications for additional sites have been made.

"The District Commissioner, Bole, reports that trade has increased, but, during the rains, which were very heavy, and owing to the main roads being under water, a good deal of the trade passed through Busunu and Bonfu."

The Commissioner of the North-Western Province states :—

"The local trade, which is more or less a minor quantity, is much the same as it was a year ago.

"The caravan trade, however, shows a distinct falling off in cattle and moshi cloth. The sheep have increased by 10 per cent. over last year, but still show a very large decrease when compared with 1911. Other items do not call for comment.

"I am informed that one reason for the decrease in cattle is that the season has not been propitious in the French country,

where 95 per cent. of the cattle, etc., come from. Another reason given is that many chiefs have complained to the authorities of the increased migration, or rather desire to find work, or trade, amongst their people, and the authorities have tried to put pressure on the people. The chiefs wish it stopped as they cannot get the young men to farm.

"I have already reported on the number of French subjects passing through Wa empty-handed, the causes of which are conscription and the bad season.

"I am also of opinion that other roads are being used by the traders, and this can be verified if statistics from Kintampo were available.

"There is also no doubt that the enforcement of quarantine regulations by the French has had some effect."

The report of the Commissioner of the North-Eastern Province demonstrates that the decrease in volume of the caravan trade passing through the North-Western Province is due to the popularity of the recently opened trade routes through the Tong Hills. He states :—

"Trade statistics for the year are attached, and although they cannot be regarded as representing accurately the whole volume of the trade which passes through the Province, they do, however, clearly indicate that there has been a marked increase over the previous year.

"The following are the principal increases :—

Horse	121
Cattle	15,450
Sheep	15,458
Donkey	1,021
Donkey load	2,840
Carrier loads	23,622
Total ...	58,512

"It is to be regretted that this volume of trade does not materially benefit the Administration of the Protectorate, although it must add very considerably to the prosperity of the merchants of Ashanti and the Colony.

"Had the caravan tax still been in force the revenue of this Province, derived from this source alone, would have amounted to £13,244.

"It is impossible to value the whole of the trade, but that of the live stock imported during the year would approximately amount to £268,605, made up as follows :—

	£	s.	d.
653 horses at £6	3,918	0	0
43,943 cattle at £5	219,715	0	0
60,752 sheep at 12s.	36,451	4	0
5,682 donkeys at 30s.	8,521	0	0
Total ...	£268,605	4	0

"The following are the total increases at the various stations :—

	1912.	1913.	Increases.	Decreases.
Navarro	43,620	59,139	15,519	—
Gambaga	5,533	8,492	2,959	—
Bawku	39,674	63,320	23,646	—
Zouaragu	8,320	24,708	16,388	—
Total	97,147	155,659	58,512	—

"The most gratifying feature from an administrative point of view is the increase of 16,388 in the Zouaragu return, which proves conclusively the entire pacification of the district. Traders now come to Zouaragu from Bawku, and all the towns along the frontier, chiefly from Zoko on the north-east of the district, which is situated on a route which is rapidly becoming popular with French traders. They then travel south on the road which passes through Tonzugu and Winduri in the heart of the Tong Hills. Prior to the establishment of the station in 1910 no traders dare wander about the district, and, except for the exchange of foodstuffs at the local markets, which were constantly raided, there was no trade of any sort.

"There has been a very severe drought in the regions between Wagadugu and Timbuctoo, and to this fact may be attributed the increase in the live stock which has been, and still is, passing to Coomassie. The crops there have failed entirely, and neither food nor water can be obtained for the animals, and consequently the owners are getting rid of their stocks as quickly as possible, so probably next year there will be a decrease.

"The bulk of the trade is in the hands of Hausas, Moshis, and other non-British subjects, who sell their wares for cash, and thus denude the Province. But signs are to be observed that our own people are commencing to take an interest in external trade, and now go so far as Yagiba and Daboya, where they exchange sheep for salt, fish, cloth, etc.

"Efforts have been made to establish a trade in bees-wax and hides, but the result has not been very encouraging. The former is prepared in small quantities everywhere, but, until traders come up and prove to the people that a demand does exist, I fear it will not be any great success. As for hides, although in nearly every compound there are a few cattle, they are never killed for consumption, but kept chiefly for the purpose of paying headmoney on women."

TABLE OF PRINCIPAL TRADE ROUTES ENTERING THE NORTHERN TERRITORIES FROM THE IVORY COAST AND UPPER SENEGAL AND NIGER AND FROM TOGOLAND.

Number of Trade Route.	Description of Route.	Volume and Nature of Trade.	Periods when used by Traders.	Remarks.
I.	From Buna. Enters the Southern Province at the ford of Vonkoro on the Black Volta River, and passes (*a*) *viâ* Sawla (Sowala) and Larabanga to Yapei and Tamale Port, and (*b*) to Bole, where it joins Trade Route No. II.	(*a*) Chiefly cattle, shea-butter and small quantities of gold dust in exchange for salt.	From December to July ...	A track also runs from Buna to Tantama, where there is a ferry; thence to Komforhosi, and joins Route II. at Nakpala (marked green on map). "Shea-butter." A vegetable fat procured from the kernel of the fruit of the tree *Butyrospermum parkii*.
II.	From San in the Valley of the Niger, Segon and Bamako *viâ* Bobo, Dionlassu and Diebugu. Enters the North-Western Province at Manoa near Lorha. The route to Wa is (*a*) *viâ* Babile, Iziri, Tansia, Nator and Cherra; (*b*) by Babile, Iziri and Sombo; (*c*) when the country is flooded the Girapa route is used occasionally (marked green). The road then passes *viâ* Kulmasa, Nakwabi and (*a*) Nakpala, (*b*) Swala to Wankuma and Bole, whence it goes south *viâ* Suripe, Wasipe, Banda N'kwanta and Jugbe. The main road proceeds *viâ* Bampewa, crossing the Black Volta River at the Buere ford and on to Kintampo and Coomassie. Another road from Jugbe—and that most frequently used by traders—crosses the Black Volta at the Bamboi ford and passes *viâ* Wenchi to Coomassie.	Herds of up to 300 cattle come down *viâ* Lorha and Wa, each in charge of a few men, who return with gold and dollars, and but rarely with kola nuts or trade goods. The volume of the cattle trade from the north has increased greatly, 15,671 cattle passed through Bole from January to July this year; the average number being reckoned at 2,000 a month. The trade in shea-butter and dawa-dawa is reported from Bole to be brisk during the rains, with an average of 2,000 loads a month. In the Southern Province:– Southwards, cattle, sheep, fowls, hides, shea-butter, dawa-dawa for cash. Northwards, cloth, copper rods and kola nuts.	The trade passing along this route from Lorha usually dwindles after the end of May, but has not done so this year, either on account of the little rain that has fallen or of the famine said to be raging in the Upper Senegal and Niger Districts. The normal trade in cattle falls off at the commencement of the rains—July to December—owing to flooded rivers.	This route, so far as the Bole District is concerned, is by far the most important of the three routes traversing that district. "Dawa-dawa." A food prepared from the beans of the tree *Parkia filicoidea*. "Kola-nuts." The fruit or nut of the tree *Cola acuminata*. In great demand among the inhabitants of the Sudan, who chew it to allay hunger and thirst. There is a steel pontoon boat on the Black Volta at the Buere ford.

III.	This route enters the North-Western Province from Upper Senegal at (*a*) Hamela and (*b*) Namora; joins up at Ulu, and runs south *viâ* Boussie, Naro and Jang to Wa, where it joins Route II.	The trade is of a general description and there is a greater proportion of men to beasts travelling along this route, who return with loads —principally of kola nuts.	The natives trade during the dry season –December to July –and return to their country to prepare their farms when the rains commence.	Used by the Wongara and Moshi natives from Boromo and adjacent villages.
IV.	Enters the North-Western Province north of Golu and runs in a south-westerly direction to Nandaw, where it joins Route III. at (*a*) Ulu and (*b*) Bonssie.	The trade is of a general description, and there is a greater proportion of men to beasts travelling along this route, who return with loads —principally of kola nuts.	The natives trade during the dry season —December to July—and return to their country to prepare their farms when the rains commence.	Used by the natives of Sette in French Grunshi.
V.	This main trade route (cleared twenty feet, and partly ditched) enters the North-Western Province at Lingemera from Leo, and, passing through Tumu and Walembele, joins up with Route II. at Wa.	Until recently this route bore the bulk of the trade passing through the North-Western Province, but Route II. now takes the greater number of cattle. The southward-bound trade is usually in cattle, sheep and goats, while large numbers of donkeys are brought down, and return loaded with kola nuts and cloth. Many head loads of shea-butter, dawa-dawa, and native blankets are carried down this route.	During the dry season steady streams of natives pass up and down this route; the former returning to make their farms, the latter to trade or find employment in Ashanti.	This route is used principally by Moshis, but natives from beyond Onagandongou, from Timbuctoo, Arabs, and, more rarely, travellers from Morocco, are to be met. There are two rivers at Wahabu and Menyon on this route which are unfordable after every rains, as they rise very quickly.
VI.	Branches off from Route V. at Tumu and runs in a south-easterly direction *viâ* Santigan to Yagaba, where it joins Route VII.	Used by small parties only, taking cattle, sheep and donkeys south, and returning with salt from Daboya.	Used during the dry season.	This route is patronized by both British and French Grunshis, and may be said to commence at Dolbezan, where traders arrive by the many tracks that converge on that village.

Number of Trade Route.	Description of Route.	Volume and Nature of Trade.	Periods when used by Traders.	Remarks.
VII.	This route enters the North-Eastern Province from Onagondongou, in French Upper Senegal, at Paha (Paga), and, passing through the villages of Chuchulliga and Kanjarga, crosses the ferries on the Sissilli and Kulpawn Rivers to Yagaba, where Route VI. meets it. It then proceeds south to Daboya, and thence *viâ* Busunu and Buipe to the ford on the Black Volta River at Gerinyatto, and on through Porta to Kintampo and Coomassie.	The trade, which is considerable, consists chiefly in cattle and sheep to the south, and in kola nuts and salt to the north.	This route is used throughout the year, subject to the "seeding-time," *i.e.*, the time for preparing the farms, when, it is stated, the French keep the natives from trading until the farms have been planted.	Used by the Moshi traders.
VIII.	This route also enters the Protectorate at Paha (Paga), but branches off from there to Navarro, the headquarters of the North-Eastern Province, and thence through Korogu to Naga, where a road branches off to the south-west through Kunkwor to Yagaba, there forming a juncture with Route VII. (This road marked green.) The main road continues through Dua, Wale-Wale, Nasia, Savelugu, Tamale, Dogankade, Masaka, Salaga, Yeji, and Prang, *viâ* Attabubu and Ejura, to Coomassie. The following subsidiary trade routes are thrown out from the main road, and are marked in green on the map :— (i) From Pong Tamale to the south-west *viâ* Kumbungu to Tamale Port (Yapei).	This route is popular, as Navarro (the headquarters of the North-Eastern Province) is felt to be a safe resting place, and, in consequence, the Government caravanserai is usually crowded. Trade consists chiefly in cattle, sheep, and Moshi cloth southwards, and in kola nuts and salt northwards. In the Southern Province the southern trade is in cattle, sheep, goats, shea-butter, dawa-dawa, native cloth, and, locally, foodstuffs for cash, and, northwards, kola nuts, brass and copper rods and cloth.	Very large caravans travel by night down the Government road from Navarro to Naga, and, in the dry weather, follow the route to Yagaba, and so on down Route VII. The main road to Tamale is both a dry and wet weather route. The remarks made above with regard to "seeding-time" apply also to this route.	There is a steel pontoon boat on the ferry at the White Volta River between Naga and Dua, and half-sections on the river at Nasia and Nabogo. Two pontoon boats are on the Volta River at the Government ferry at Yeji. Tamale Port (Yapei) : this is the great salt depôt for the Northern Territories. The salt is brought up in bags from Addah and Akuse *viâ* the Volta River. *Note.*—The French Moshis are to be found scattered all over the country in the North-Eastern Province at certain times of the year, and are encountered on the most remote by-paths searching

	(ii) From Tamale *viâ* Sangrawla to Tamale Port. (iii) To the south-east from Savelugu, joining Route XI. at Palbe. (iv) From Tamale, joining Route III. at Yamalaga. (v) To the south-west from Masaka, *viâ* Kakosi, and crossing the Katakunji Ferry to Yeji. (vi) From Salaga *viâ* Krupi to Dakar River mouth, and on to British Kratchie. (vii) From Yeji along the left bank of the River Pru to Prang. A road branches off from route. (viii) Between Naga and Dua ferry, and runs in a south-westerly direction to Yagaba, where it joins Route VII. (marked green on the map).			for food which they are not able to find in their own country. It is not unlikely that they are, but too often, the bearers of infectious diseases.
IX.	Enters the Protectorate north of Boku and passes south through Bolgatanga, Tong, Paragu, and Wulugu to Wale Wale, where it joins the main trade Route VIII. Branch roads run from Bolgatanga (*a*) *viâ* Serigu (Shirigu) to Naga, and (*b*) *viâ* Balunge (Belungu) direct to the Naga ferry, where they join Route VIII.	This route, until recently of no importance, has become popular since it was opened after the subjugation of the Tong Hill marauders (*vide* "Northern Territories Annual Report" for 1913, Imports and Exports). Trade to the south: cattle, sheep, and shea butter; to the north: kola nuts and salt.	Route IX. is described as the "wet weather route": its branches (*a*) and (*b*) as the "dry weather routes."	French native subjects from across the border trade locally in sheep and foodstuffs with the natives of Bongo (where there is a big market), Bolgatanga and Zouaragu (the headquarters of the Northern Territories Company of the Gold Coast Regiment). There is a section of a steel pontoon boat at the Paragu ferry.
X.	The route enters the Protectorate north of Arabe, and, tapping the Kulmasa Market, passes south to Zouaragu.	Of local importance only. Sheep are brought down and the traders return with salt. The chief trade is said to be in "soki," *i.e.*, Guinea corn prepared in a certain way for the making of "peto," native beer.	Used throughout the year.	The Native traders come from French Busanga country, where the "soki" is prepared.

Number of Trade Route.	Description of Route.	Volume and Nature of Trade.	Periods when used by Traders.	Remarks.
XI.	From Tenkudogo and Fada N'Gurma in French territory, this route enters the Protectorate north of Bawku and divides at Kugri; the western route passing *viâ* Zongoire to Gambaga: the eastern, south through Sinebagga to Gambaga. The main route then runs south through Timboro and Suguri to Karaga, where it bifurcates and runs (*a*) south and west *viâ* Ga, Jimle and Palbe to Turu, and (*b*) south and *viâ* Patenga, Zan, Kpabia and Zankum to Turu; then on to Dogankade where it merges into Route VIII. [(*b*) is known as "the old military road"]. This route is also linked up with Route VIII. by the Government road running south-west from Gambaga *viâ* Maibindiga and Paragu to Nasia. At Maibindiga a road (formerly a main trade route) passes through Wale-Wale and Wungu, and, crossing the White Volta at Wiema ferry, proceeds to join Route VII. at Yagaba. It is but seldom used to-day. (Marked green on the map.)	A large trade in cattle, sheep and Moshi cloth pours south along this route. A number of horses are also taken down, the traders returning with kola nuts and salt. In the Southern Province cattle, sheep, goats, horses, shea-butter, dawa-dawa and a small amount of foodstuffs pass down, while kola nuts, salt, brass and copper rods and cloth pass north. (*Vide* "Northern Territories Annual Report for 1913." "Imports and Exports.")	The cattle trade in the North-Eastern Province is stated to be very regular throughout the year, falling off to a certain extent during the heavy rains, when great difficulty is experienced in crossing the swollen rivers. This, however, has its compensations in the shape of abundant grass and water supplies, and the cattle brought down during the rains are in a much healthier condition than those driven down during the dry season. The "old military road" suffers in the dry season from want of water, and in the wet from the Gonyiri Swamp, the worst in the Protectorate, which has to be crossed. In the Southern Province the majority of the cattle and sheep pass through Tamale during the first six months of the year.	In order to avoid the ascent of the steep scarp north of Gambaga, a certain number of cattle are taken by the road (marked red on the map), *viâ* Gogo or Binduri, Tili and Nangudi to Zouaragu, whence they are driven south along Route IX., or, in the dry season, *viâ* Naga and Yagaba. Large numbers of Bazaberimis, Kotokolis and Moshis pass down from the north annually during the months of December and January to find work in Ashanti and the Colony. Some return in a few months, others stay away from their country for some years.
XII.	From Sansanne-Mangu. Enters the North-Eastern Province east of Malerigu and on to Gambaga.	Local trade in cloth, brass rods and other goods of European manufacture, chiefly German.	Throughout the year except at "seeding-time."	—

XIII.	From Yendi. Passes through the Bongo market to Gambaga.	As above.	As above.	—
XIV.	From Sansanne Mangu-Kotokoli. Enters the Southern Province at Patenga and then runs in a south-westerly direction *via* Garimo, Sihun and Tamale to Tamale Port.	Soap, mats, palm-oil and native (dzugu) cloth. Traders return with kola nuts and salt for cash.	As above.	
XV.	From Yendi. Enters the Southern Province at Ga and joins Route XI. at Kpabia (Preventive Station).	As above. Traders return with kola nuts and mixed goods for cash.	As above.	
XVI.	From Jonayile. Enters the Southern Province at Kadenge (Preventive Station), in the Salaga District, and joins the main route (No. XI.) at Dogankade (Preventive Station).	A local trade in soap, mats and foodstuffs.	As above.	—
XVII.	From Bimbila. Enters the Southern Province at Kunkwa (Preventive Station), and joins the main route (VIII.) at Salaga.	Soap, mats and foodstuffs. Kola nuts and general goods for cash.	As above.	—
Local Route	This route, marked green on the map, runs from Wa *via* Bulengu (Bullenga), Dusi and Jinfronu to Daboya.	Traders proceed from Wa to Daboya to purchase salt; cattle and donkeys are met on the road, but not in large numbers.	Used throughout the year, except during periods of heavy rains and floods.	Used by traders from Dagarti and French Lobi, and who, on returning, generally leave the main road at Bulengu, and proceed to their villages by the nearest "bush tracks."

Tamale,
28th September, 1914.

C. H. ARMITAGE,
Chief Commissioner of the Northern Territories.

[*Enclosure* 3.]

TABLE OF PRINCIPAL TRADE ROUTES ENTERING ASHANTI FROM THE IVORY COAST AND TOGOLAND.

Number of Trade Route.	Description of Route.	Volume and Nature of Trade.	Remarks.
XVIII.	From Hong and Hant through Bonduku, entering the Western Province of Ashanti at Sikasiko, and thence by Nkoransa to Coomassie. Another branch from Sikasiko joins Route XIX. at Puliano.	Chiefly cattle, hides and kola; some native cloths.	—
XIX.	Another route from Bonduku, entering Ashanti near Goresua, thence to Puliano and from Puliano *viâ* Berekum and Odumase to Coomassie.		Little used since fall in price of rubber.
XX.	From the southern and central portion of the Ivory Coast, entering Ashanti near Pamo and joining Route XIX. at Berekum.	—	Little used since fall in price of rubber.

YELLOW FEVER COMMISSION (WEST AFRICA).

CORRESPONDENCE RELATING TO THE INTRODUCTION OF INFECTION INTO THE WEST AFRICAN COLONIES BY SEA.

THE SECRETARY OF STATE TO THE GOVERNORS OF THE BRITISH DEPENDENCIES IN WEST AFRICA.

Downing Street,
16th December, 1913.

SIR,

I have the honour to inform you that the Yellow Fever (West Africa) Commission are anxious to have reliable information in regard to the conditions of the sea-borne traffic of the West African ports, with special reference to the circumstances favouring the introduction of Yellow Fever by this means.

They would, therefore, be glad if from time to time, as occasion serves, the port health authorities would make a careful examination of vessels of every class trading with the ports within your administration, with a view especially to determining the presence and, when present, the degree of prevalence of the *Stegomyia* mosquito on board, both in the larval and in the adult stage. The enquiry need not be exhaustive; opportunities for the examination would, presumably, be furnished by the ordinary routine of the official duties of the investigating officers; and they would be best able to determine how many vessels of each kind (from the mail steamer to the canoe) would furnish a satisfactory estimate of the general condition of the shipping of the class. They would, of course, at the same time, note any other features of the traffic likely to have a bearing on the question.

I have, &c.,

L. HARCOURT.

GAMBIA.

THE GOVERNOR TO THE SECRETARY OF STATE

(Received 10th July, 1914.)

Government House, Bathurst, Gambia,
20th June, 1914.

SIR,

I have the honour to enclose a report submitted by the Senior Medical Officer, on the question of the prevalence of the *Stegomyia* mosquito on board vessels trading with this port.

It is possible that more definite information on the subject may be obtainable hereafter through the Customs Department, and I will refer the question to the Receiver-General.

I have, &c.,

EDWARD J. CAMERON,
Governor and Commander-in-Chief.

[*Enclosure.*]

Medical Office, Bathurst, Gambia,
(No. 195.) *17th June*, 1914.

SIR,

I have the honour to report that investigations made during the last six months as to the presence of larvæ or adult *Stegomyia* on boats trading in the ports of the Gambia have been confined to those cases where it has been requisite for the Medical Officer of Health to visit and inspect such ships.

The examinations made on such occasions have included steamers and sailing boats, but have never discovered the presence of larvæ or adult *Stegomyia*.

On inquiry, the officers of steamers have in some cases stated that there are a few mosquitoes on board, but I have not been able to obtain specimens for identification.

I have, &c.,

A. E. HORN,
Senior Medical Officer.

THE GOVERNOR TO THE SECRETARY OF STATE.

(Received 19th December, 1914.)

Government House, Bathurst, Gambia,

28th November, 1914.

SIR,

I have the honour to enclose copy of a report to the Receiver-General by the Boarding Officer of the port, on the subject of the prevalence of the *Stegomyia* mosquito on vessels trading with Bathurst, together with copy of a minute from the Senior Medical Officer commenting on the same.

I have, &c.,

EDWARD J. CAMERON,

Governor and Commander-in-Chief.

[*Enclosure* 1.]

Attached is list of vessels inspected by me. The result of my inspection showed a total absence of mosquitoes in the larval or adult stage. The only reason for this was—according to my belief and that of several ships' officers whom I have interviewed on the subject—that any mosquitoes which might have been carried from the last port of call were completely flown away at sea before the ship's arrival at next port.

It was only on one solitary occasion that I discovered some mosquitoes on the "Muraji," which arrived and remained outside on the night of 15th July and entered the harbour on the following morning. I enquired about this from the purser, who reported that there were no mosquitoes on board when the ship dropped anchor on night of 15th, and that it was about 2 o'clock in the morning that the presence of mosquitoes from Bathurst was felt on board.

No inspection was made of ships in quarantine, but the masters of these vessels in every case reported total absence of mosquitoes.

S. F. LEIGH.

20th November, 1914.

List of Vessels Inspected.

Name of Vessel.	Where from.	When arrived.	Remarks.
Muraji, s.s.	Liverpool	16 July, 1914	—
Obuasi, s.s.	London	17 ,,	—
Eloby, s.s.	Sierra Leone	18 ,,	—
Henriette Woermann, s.	Hamburg	22 ,,	-
Rufisque, cutter	Foundiougne	22 ,,	-
Selika, s.s.	,,	23 ,,	
Prahsu, s.s.	Sierra Leone	26 ,,	
Ansonia, s.s.	Marseilles	27 ,,	In quarantine.
Tibet, s.s.	,,	28 ,,	
Liberia, s.s.	Conakry	28 ,,	—
Addah, s.s.	Liverpool	29 ,,	—
Bathurst, s.s.	Hamburg	1 August, 1914	
Tendaba, s.s.	Dakar	4 ,,	In quarantine
Nigeria, s.s.	Sierra Leone	8 ,,	—
Sandu, s.s.	Rufisque	9 ,,	
Rufisque, cutter	Foundiougne	9 ,,	-
Accra, s.s.	Liverpool	14 ,,	—
Ormidale, s.s.	London	15 ,,	—
Akabo, s.s.	Liverpool	20 ,,	
Ecaterina Couppa, s.s.	Foundiougne	20 ,,	In quarantine.
Rufisque, cutter	,,	27 ,,	-
Eboe, s.s.	Liverpool	31 ,,	
Prahsu, s.s.	,,	3 September, 1914	
Dioudiou, motor boat	Foundiougne	4 ,,	
Rufisque, cutter	,,	6 ,,	
Appam, s.s.	Liverpool	10 ,,	Troopship; no inspection.
Tendaba, s.s.	Dakar	11 ,,	In quarantine.
Combo, s.s.	,,	11 ,,	,,
Akassa, s.s.	Liverpool	15 ,,	
Rufisque, cutter	Foundiougne	21 ,,	
Gando, s.s.	Liverpool	23 ,,	
Sandu, s.s.	Dakar	23 ,,	
Cromarty, s.s.	Rufisque	25 ,,	
Addah, s.s.	Sierra Leone	25 ,,	
Memnon, s.s.	Rotterdam	27 ,,	
Mungo Park, s.s.	Dakar	27 ,,	In quarantine.
Accra, s.s.	Sierra Leone	29 ,,	
Ramatoulie Joof, cutter	Carabane	5 October, 1914	
Tamsir, cutter	Foundiougne	8 ,,	
Rufisque, cutter	,,	8 ,,	
Sandu, s.s.	Dakar	12 ,,	
Aburi, s.s.	Liverpool	16 ,,	
Stamboul, s.s.	Marseilles	16 ,,	-
Ayr, s.s.	Foundiougne	17 ,,	-
General Dodds, s.s.	Dakar	17 ,,	—
Agberi, s.s.	Sierra Leone	17 ,,	-

LIST OF VESSELS INSPECTED—*continued.*

Name of Vessel.	Where from.	When arrived.	Remarks.
Ebatoulie, cutter ..	Rufisque ..	25 October, 1914 ..	—
Louis, cutter	,,	26 ,, ..	—
Guetty, motor boat	Foundiougne	27 ,,	—
Cecil H. Lord, schooner	Maio ..	7 November, 1914	—
Diana, schooner ..	,,	7 ,, ...	—
Rufisque, cutter ...	Foundiougne	9	—
Patani, s.s.	Sierra Leone	10	—
Gergovia, s.s. ...	Marseilles ...	12 ,, ..	—
Elector, schooner ..	Maio ..	16 ,, ..	—
Gambia, schooner ..	,,	17 ,, ...	—

20th November, 1914. S. F. L.

[*Enclosure 2.*]

I would suggest that a copy of the foregoing report be forwarded to the Secretary of State. As these observations have now been conducted throughout the rainy reason and a great part of the dry season without any positive result, it does not appear probable that ships calling at Bathurst are likely to bring infected mosquitoes from other ports.

A. E. HORN.

27th November, 1914.

SIERRA LEONE.

THE GOVERNOR TO THE SECRETARY OF STATE.

9th December, 1913.

SIR,

I have the honour to transmit herewith a copy of a report by the Comptroller of Customs on the trade carried on between Sierra Leone and the neighbouring Colonies by means of native craft for the years 1910-1913.

The report has been obtained at the suggestion of the Principal Medical Officer, a copy of whose minute on the subject is enclosed.

I have, &c.,

E. EVELYN,

Deputy-Governor.

[*Enclosure* 1.]

The following table (*see* page 221) indicates the extent and direction of the trade carried on by means of native craft between Sierra Leone and the neighbouring Colonies.

2. It is evident that the trade conducted by means of native craft is not confined to Freetown and Sherbro. For this reason, although only these two ports are mentioned in your minute, I quote in addition figures for three sub-ports. The table furnishes a complete statement of the small craft trade of this Colony with its neighbours.

3. The great bulk of this class of trade is with the adjacent territory of French Guinea. It is of a very general character, though largely consisting of interchange of natural products. Imports from French Guinea are mainly goods of European manufacture; exports thereto are local produce and general European goods, the former accounting for more than half the yearly value.

4. Much of the live stock imported into Sierra Leone is brought from French Guinea in the larger class of native craft, principally to Mahela, which port, as the table indicates, has by far the most intimate connection of any Sierra Leone port with any of the neighbouring Colonies.

5. Trade with Portuguese Guinea is very similar to that described above, Freetown being the only port which has oversea communication with that Colony.

6. Mano Salija, in the south of the Colony, and Gene, on the Mano River, provide convenient bases for trade with Liberia. Here, again, the small trade which is carried on is of a general nature, though the convenience of Mano Salija as a port of shipment induces Liberian farmers to send an appreciable quantity of produce to that port *viâ* British Gene.

7. In connection with the object of this report, it may be of useful interest to state that a ferry canoe crosses the Manoe River between Liberian Gene and British Gene some eight times daily, carrying passengers and goods. It is not easily possible to estimate the number of persons who use the ferry in the course of a year, but it is evident that a large number of people must enter the Protectorate of Sierra Leone by this route.

8. The transit trade on the Mano River does not affect Sierra Leone to any appreciable extent. It is not trade in the strict meaning of the term, consisting, as it does, of cargoes of general

Port.	1910. Craft trading to				1911. Craft trading to				1912. Craft trading to				1913.* Craft trading to			
	French Guinea.	Portuguese Guinea.	Liberia.	Men.	French Guinea.	Portuguese Guinea.	Liberia.	Men.	French Guinea.	Portuguese Guinea.	Liberia.	Men.	French Guinea.	Portuguese Guinea.	Liberia.	Men.
Freetown ...	54	4	—	781	34	5	—	585	36	2	—	356	28	2	—	341
Sherbro ...	—	—	—	—	2	—	—	46	1	—	—	22	—	—	—	—
Mahela ...	339	—	—	1,508	219	—	—	1,057	343	—	—	1,489	25	—	—	897
M. Salija ...	—	—	3	16	—	—	2	4	—	—	5	26	—	—	4	28
Gene ...	—	—	—	—	—	—	—	—	—	—	6	34	—	—	3	15

* Up to end of September.

goods—largely trade spirits—shipped from a Liberian port on the seaboard to another Liberian port on the river which forms the boundary between Liberia and Sierra Leone.

9. In the above table are included those sloops and cutters which trade regularly between Sierra Leone and neighbouring Colonies. This accounts for what may seem at first sight a number of men disproportionately large to the number of vessels engaged. These vessels trade to Freetown and Sherbro only. A further explanation of the large number of men engaged is furnished by the fact that it is usual for these small craft to carry hands sufficient to row or paddle in the event of the vessel being becalmed.

A. P. VIRET,

17th November, 1913. *Comptroller of Customs.*

[*Enclosure 2.*]

I happen to know that the information with regard to trade routes was originally asked for in connection with the controversy as to the origin of the outbreak of Yellow Fever at Freetown in 1910—the possible sources of infection being the point at issue.

I am given to understand that a considerable trade is carried on between Sierra Leone and other Colonies adjacent by means of native vessels, and I suggest that a report on this trade be called for from the Harbour Master and Comptroller of Customs, and the information forwarded to the Secretary of State in order that his knowledge of the subject may be as complete as possible.

T. E. RICE,

8th November, 1913. *Principal Medical Officer.*

THE GOVERNOR TO THE SECRETARY OF STATE.

Government House, Sierra Leone,

31st July, 1914.

SIR,

With reference to your despatch of the 16th December last, in which you asked that the port health authorities should be instructed to make a careful examination of vessels of every class trading with the ports of this Colony, with a view to determining the presence, and when present, the degree of prevalence of the *Stegomyia* mosquito on board, both at the larval and at the adult

stage, I have the honour to transmit herewith, for your information, two reports which have been furnished by the Senior Sanitary Officer, on :—

(*a*) Prevalence of mosquitoes on board ships calling at Freetown ; and

(*b*) Presence of mosquitoes on vessels other than steamers.

Investigation (*a*) was carried out during the dry season, and (*b*) during the wet season.

The investigations have been carried out in as thorough a manner as possible under the circumstances.

I have, &c.,

E. M. MEREWETHER,

Governor.

[*Enclosure* 1.]

PREVALENCE OF MOSQUITOES ON BOARD SHIPS CALLING AT FREETOWN, SIERRA LEONE.

This investigation was carried on from the 8th of April to the 24th of May, 1914. During that period twelve ships were boarded and examined. A tabulated list of the ships is appended.

The following are the names of the vessels with the name of the port from which it came, and the number of ports of call between that and Freetown :—

Name of Ship.	*Sailing from.*	*Number of ports of call.*
s.s. "Elobi" ...	Forcados	11
s.s. "Lothai Bohlen"	Assinie	8
s.s. "Bassam" ...	Calabar	4
s.s. "Patani" ...	Freetown to Sherbro and back	1
s.s. "Gando" ...	Opobo	13
s.s. "Teneriffe" ...	Half Assinie	3
s.s. "Togo" ...	Cotonou	—
s.s. "Akassa" ...	Akassa	16
s.s. "Nembe" ...	Forcados	3
s.s. "Henrietta Woermann"	Assinie	11
s.s. "Warri" ...	Sapeli	13
s.s. "Boma" ...	Sapeli	12

Special attention was paid to examination of (1) forecastle, (2) cabins, (3) holds. In addition to searching for live specimens of mosquitoes all vessels containing water, fresh or salt, found on

board were examined for the presence of larvæ. Inquiries were also made regarding the occurrence of illness on board during the voyage, the nature, duration, and result of such illness, the diagnosis being confirmed, where possible, by the taking of blood films.

In most instances the parts of the vessels examined were gone over twice, the second occasion being made to cover the usual period of mosquito activity, viz., from six o'clock or thereabouts, onwards. Where the vessel remained only a short time in port, this of course could not be done. To carry out these investigations thoroughly, it was necessary to enlist the sympathies of both officers and crew, and in this I must say I was very fortunate, for on practically all of the vessels I had the active co-operation of all on board, so much so, indeed, that many new and strange "mosquitoes" were brought to me from time to time, including even our old friend "Daddy longlegs" in a slightly reduced size. I had also to attend one or two night calls in order to capture a mosquisto that someone had heard singing about his head. Thus where mosquitoes were unable to be found on board a vessel, I think it may fairly be taken as pretty certain that there were none on board.

Wherever in the tabulated list it appears that no holds were examined, it means that they were too full of cargo to admit of being entered.

A mosquito net was also taken on board each vessel for the purpose of setting "live baits," but no suitable occasion arose in which to make use of it.

Out of the twelve ships visited, mosquitoes were discovered in three only, namely, the s.s. "Patani," s.s "Henrietta Woermann," and s.s. "Warri."

With regard to the first of these, the s.s. "Patani," I made a special journey in her on 17th April, to Sherbro Island, which lies 90 odd miles along the Sierra Leone coast in a south-easterly direction. After a stay of about eighteen hours at Sherbro we returned to Freetown. On the journey to the island I had ample time to make a very thorough examination, and was able to convince myself that we had not a mosquito on board. After covering about two-thirds of the journey the Captain found it necessary to drop anchor, so we passed the night on the open sea out of sight of land. Up to a late hour that night I found no sign of mosquitoes and my own cabin was certainly quite free of them. Next day (18th April), about noon, we anchored in Sherbro River, *i.e.*, the strip of tidal water separating the island from the mainland. This water has only a very

narrow navigable channel, so that vessels anchored in it are of necessity close to the mangrove swamps lining the river side. The remainder of the 18th was spent in unloading cargo from the vessel, lighters being sent from the town of Bonthe on the island for that purpose.

That night mosquitoes were present on the vessel, and after some hunting I was able to capture six specimens ; three in the black crew's quarters, one in the white crew's, one in the lavatory, and one in my own cabin. The following day (19th April) we left Sherbro for Freetown, and as we did not arrive there till late at night I had time to go over the ship again, with the result that I obtained a further nine specimens from the following places : two from the dining saloon wall, three from the cabin of the second officer, three from that of the third officer, and one on the outside of my mosquito curtain early on the following morning. On this day (20th) I went on shore, but as the vessel was remaining in the harbour another day I returned and passed the night on board. The result of this night's search was : two from the white crew's quarters, three in the native quarters, one in the second officer's cabin, and three in my own cabin.

All the mosquitoes obtained were discovered in a great variety of places in the vessel ; for example, on the walls in dark corners, from the ceilings, amongst the folds of berth curtains and in the curtains over port holes, behind swing looking-glasses, under settees, and, in fact, wherever there was a dark or shaded place where they could hide. In the forecastle, where the lights were dimmer, some were caught on the wing whilst flying around the electric bulbs. For the purpose of searching the various dark corners, I used an electric bull's-eye lamp with powerful dry battery capable of giving a continuous light.

The two foreholds of this vessel were examined on both the outward and return journeys, but on neither occasion was I able to demonstrate the presence of mosquitoes.

In fact, no flying insects of any sort seemed to be present, whereas in the holds of all the other vessels examined, moths and a species of small flying beetle were always to be found, the shining of the light invariably bringing them out of their corners. Possibly the absence of these creatures on this particular boat might be accounted for by the nature of the cargo, which was composed mainly of tins of kerosene.

In all twenty-four mosquitoes were captured, and identification showed them to consist of the following :—*Culex decens*=12, *Pyretophorus costalis*=11, *Ochlerotatus* (? sp.)=1.

Anophelines were, therefore, present to the extent of 50 per cent., and of the twelve, ten were females, the one specimen of *Ochlerotatus* being a male.

Of the *Culicines*, four were males and eight females. Both *Anophelines* and *Culicines* were obtained in equal numbers from the forecastle and also from the cabins.

As regards the arrival on board of these mosquitoes, there are two sources from which they might have come, viz., in the three empty lighters sent out from Bonthe to take off the cargo, or from the mangroves which lined the river and which were only about four hundred yards from the vessel. I think the latter seems the more likely source.

The next vessel, the "Henrietta Woermann," had just arrived from Sherbro Island when I visited her. She had passed two nights there, remaining eighteen hours altogether, and previous to calling there had been travelling up the coast from Assinie. At none of the other ports however, with the exception of Freetown, had the vessel been nearer the shore than half a mile, so that, in all probability, the mosquitoes got aboard at Sherbro. Both officers and crew said that they had hardly been troubled at all by them while anchored there, and a considerable searching of the forecastle was necessary, before I finally succeeded in dislodging one from the tuft (leaves) of a pineapple suspended from the edge of one of the bunks. Owing to the vessel only remaining a short time in Freetown harbour, I had no time to go through the other parts of the vessel except the cabin of the third engineer, who came to me saying that he had heard mosquitoes "singing" in his room. After some little searching we finally discovered two in the folds of the berth curtains. One I managed to capture, but the other escaped from the cabin. The two mosquitoes caught proved to be *Culex duttoni*, both females.

The third vessel on which mosquitoes were caught, namely, the s.s. "Warri," had travelled up from Sapele and Warri. In addition to those two, she had called at eleven other ports, but at all of the latter she had lain at least a mile and a half from the shore. Cargo was taken on at three ports only, besides Sapele and Warri, namely, Barracoe, Addah and Winnebah. It consisted of palm kernels in sacks and was brought out to the vessel in each case in open surf boats. It seems practically certain, therefore, that the mosquitoes found on this ship must have come all the way from the creek ports of Sapele and Warri, as it appears impossible for

them to have been brought out by the surf boats. Nor could they have come on at Freetown, since the vessel was anchored practically a mile out and I boarded her as soon as she arrived, which was in the day time. Moreover, the larval index of Freetown had just been shown by Dr. Orpen, Acting Medical Officer of Health, to be 0·4. The specimens captured were obtained from the following parts of the ship, viz., seven from the purser's cabin, three from the third mate's, one from the cabin of the second mate, and one from that of the chief engineer. Next morning a search was made in the forecastle, and after some hunting a single specimen was caught in the native quarters in the dark corner formed by the stem of the vessel.

The time occupied in the voyage from Warri to Freetown was sixteen days and about nineteen from Sapele.

Identification of the captured mosquitoes gave the following result:—*Culex duttoni*=3, *Stegomyia fasciata*=1, *Culex pipiens*=2, *Culex* (? *pipiens* type)=6, *Culex* (? sp.=1). All were females, with the exception of the *Stegomyia*, which was a male. The last named was captured in the cabin of the second officer.

Holds.—In none of the holds of any of the vessels was I able to detect the presence of mosquitoes. The only winged insects found were moths and a species of small flying beetle. These were present in all the holds with the exception of those which carried the kerosene. It seems to me unlikely that mosquitoes are carried on board these vessels in the cargo, since the latter consists, for the most part, of sacks of palm kernels, nuts, etc. A different state of affairs might of course obtain if fruit were also shipped as cargo, as one can readily imagine mosquitoes being carried out lurking in the many interstices of a large bunch of bananas, for instance. On the other hand, even if a few did find their way into a hold with the cargo they would want to get out in order to feed, when the chances were very great of their being blown overboard, since the hatches to the holds are placed on the open deck. Assuming that they did find their way into a cabin, and have gorged themselves on the unfortunate occupant, the probabilities are that they would be too sluggish to venture out on the open deck again and would simply hide themselves away in some dark corner in the cabin.

According to the officers and men of all the vessels the only places where mosquitoes give any trouble are Forcados and the various creeks thereabouts, Opobo and its creeks, and at Benin and Brass further along the coast. Okrika and Port Harcourt were

mentioned by all as the two worst. Further, I found them unanimous in stating that as soon as a vessel gets out to the open sea, any mosquitoes that have been carried out almost invariably disappear from the ship, more especially if there is a breeze blowing. They do admit, however, that, exceptionally, mosquitoes may remain on board for many days, but say that that occurs only when the weather is particularly calm and the vessel keeping more or less close to the shore and not taken long between ports. The great variation in the extent to which vessels sailing up these infected creeks are troubled by mosquitoes is interesting to note. For instance, those on board the s.s. "Warri" were greatly tormented by them, whilst the s.s. "Boma," which covered exactly the same ground about ten days later, was hardly troubled at all. Possibly the presence or absence of wind, or the direction from which it is blowing, may account for this more or less.

There were fourteen cases of illness amongst the twelve ships during the voyage. Nine of these seemed to be malarial, one intestinal, one Yellow Fever, and three with pyrexia and headache. Two died, one, according to the ship's surgeon, of malaria and hyperpyrexia, the other was the Yellow Fever case. The latter patient was taken ill and, after five and a half hours' illness died. The vessel, the "Nembe," was then at Burutu. The case was reported as Yellow Fever by the Port Authority and the ship was fumigated at Forcados. I had the opportunity of going through this vessel very thoroughly, but found no trace of mosquitoes. The whole ship still smelt very strongly of burnt sulphur.

Regarding the breeding of mosquitoes on board these ships, open receptacles containing more or less permanent collections of water were conspicuous by their fewness. The only collections of fresh water, in fact, that I was able to find, apart from that in drinking glasses in the cabins, were a couple of inches or so in three boats and a barrel about half full in another ship. A third ship had some water in three boats, which was very faintly saltish. The fresh water supply of the ship is closed in and the necessary quantities are served out from day to day.

No doubt the absence or scantiness of water in boats or other parts of the vessels can be accounted for by the fact that this investigation was carried out during a portion of the dry season. A different state of matters might, of course, obtain during the rainy season and sufficient water be left in a boat long enough to permit of mosquitoes breeding out. I am told, however, that during the

rains the plugs are left out of the boats, for fear the weight of water after a heavy shower should burst open the planking. Still, small pools might easily remain between the ribs, though continued washing with rain would tend to make them unfavourable hatching places. The above remarks would also apply in the case of salt water collections, with the exception perhaps of that in the bilges. Here there seems to be a more or less permanent supply of water, fed by drainings from the decks, from leakages between plates, and through the bearing at the stern end of the propeller shaft. The only place where the bilges are open is in the "tunnel" through which the propeller shaft runs, and I have been told by engineers that mosquitoes are sometimes found down the tunnel. Probably they get drawn down by the strong draught that comes down the tubular ventilators. As a matter of fact, *Stegomyia* has been found breeding in the bilge water. In the one bilge I examined the water was reached only after considerable difficulty, on account of various structures over the opening and the shallowness of the water in the bilge. Repeated scoopings failed to reveal any larvæ.

Nets.—Mosquito nets were seldom used on any of these vessels. As a matter of fact, I only came across one or two amongst the sailors, though all the officers possessed them. On one of the vessels, it is interesting to note, mosquito nets were supplied by the Company for all the officers and crew. This vessel was a Hamburg-Amerika trading boat which had been put on the African service. The nets were retained by the chief steward and given out when applied for. Moreover, circles of gauze wire were also on board for fitting into the port holes, and gauze frames for the doorways. None of these, however, seem to have been used on this voyage, at least by any of the crew, and on all the vessels the officers only used their nets during the few days the vessels were anchored up the various creeks and discarded them immediately they reached the open sea, preferring to be bitten by any mosquitoes remaining on board to enduring the additional stuffiness of a mosquito net in an already hot cabin.

It is doubtful indeed, if mosquito nets are of much use on board ship as, owing to the small area of the berths both in the cabins and in the crew's quarters, but particularly in the latter, divers portions of the occupant's anatomy are almost certain to be in contact with the net at some time or other during the night, and as night wear in the tropics is very often reduced to what is practically the vanishing point, the ever watchful and ready

mosquito experiences little or no difficulty in obtaining her daily bread. In many instances also, the nets in use seemed to have been purchased without any idea of what the size of the mesh ought to be, as some that I saw were certainly capable of letting mosquitoes through, and one or two that I measured proved to have a mesh of twelve to the inch.

Identification of the mosquitoes caught was kindly carried out in the laboratory by Drs. G. G. Butler and W. B. Johnson.

In conclusion, I should like to express my appreciation of the courteous manner in which both the German and British companies and their officers on the various vessels treated me, and for the facilities they granted me for the carrying out of the investigation.

J. M. Clark.

LIST OF SHIPS EXAMINED.

Name of Ship.	Ports of Call and Time in Each	Number of Crew.	Sickness during Voyage.	Parts of Vessel Examined.	Mosquitoes Found.	Receptacles containing Water.	Larvæ Found.	Remarks.
s.s. "Elobi"	Forcados ... 2 days Kotonon ... 4 hours Accra ... 3 hours Saltpond ... 12 hours Cape Coast Castle ... 6 hours Secondee ... 2 days Axim ... 1 day Assinie ... 1 day Grand Bassam 2 days Lahon ... 1 day Cape Palmas 12 hours Freetown ... 1 day	White ... 11 Black ... 10 Krooboys 60	None...	Cabins, saloons, etc. A few Forecastle — Examined Holds—None	None	Boats Several contained salt water Other vessels — Buckets in lavatory and washhouse	None	—
s.s. "Lothar Bohlen"	Assinie ... 1 day Half Jack ... 1 day Cape Palmas 1 day Sinoe ... 1 day River Ses ... 1½ days Grand Bassam 1½ days Cape Mount 1½ days Monrovia ... 4 hours Freetown ... 5 hours	White ... 28 Krooboys 60	None...	Cabins, etc.— Several Forecastle—Yes Holds—One	None	Boats Two with salt water; 2 in. Other vessels None	None	—
s.s. "Bassam"	Calabar ... 5 days Lagos ... 6 days Addah ... 12 hours Accra ... 1 day Sierra Leone 4 days	White ... 23 Black ... 11 Krooboys 48	Chief Officer was ill for about a week with subtertian malaria. Recovery	Cabins, etc. —All but two Forecastle—Yes Holds—Two	None	Boats None ... Other vessels — Barrels half full in lavatory. Some water round winches	None	A blood film showed the parasites.

Name of Ship.	Ports of Call and Time in Each.	Number of Crew.	Sickness during Voyage.	Parts of Vessel Examined.	Mosquitoes Found.	Receptacles containing Water.	Larvæ Found.	Remarks.
s.s. "Patani"	Freetown ... — Sherbro ... 22 hours Freetown ... —	White ... 20 Black ... 23 Krooboys 30	None...	Cabins, etc.—All Forecastle—Yes Holds—Two	14 10 None	Boats—Two with some salt water Other vessels—A small bucket half full hanging in one of the life-boats. Water fresh	None	—
s.s. "Gando"	Opobo ... 1 week Addah ... 1 day Accra ... 1 day Winnebah ... 1 day Appam ... 1 day Secondee ... 1 day Axim ... 1 day Grand Bassam 1 day Lahon ... 1 day Cape Palmas 1 day Cess ... 2 hours Grand Bassam 1 day Monrovia ... 1 day	White ... 25 Black ... 25 Krooboys 52	Four of the white crew were ill for four or five days between Secondee and Monrovia. Diagnosed as malaria by the surgeon. Recovery in each case.	Cabins, etc.—Two Forecastle—Yes Holds—None	None	Boats—Three contained some water slightly saltish Other vessels—None	None	—
s.s. "Teneriffe"	Half Assinie $\frac{1}{2}$ day Grand Bassam 3 days Sherbro ... $1\frac{1}{2}$ days	White ... 23 Black ... 8 Krooboys 42	None...	Cabins—Six ... Forecastle—Yes Holds—One	None	Boats—One with a little slightly saltish water Other vessels—None	None	—
s.s. "Togo"	—	—	None...	Cabins—One ... Forecastle—Part Holds—None	None	Boats—None Other vessels—None	None	This vessel only came into Freetown for water and left very soon, allowing no time for examination.

s.s. "Akassa"	Akassa ... 1 day Brass ... 2 days Forcados ... 1 day Sapele ... 3 days Warri ... 4 days Benin ... 7 days Cotonou ... 1 day Accra ... 1 day Saltpond ... 12 hours Cape Coast Castle ... 12 hours Secondee ... 1 day Axim ... 1 day Assinie ... 12 hours Grand Bassam 1½ days Cape Palmas ½ day Grand Cess ½ day	White ... 38 Black ... 12 Krooboys 56	The second engineer was taken ill at Saltpond, and, after four days' illness, died. The ship's surgeon diagnosed malaria with hyperpyrexia. When I left the ship three others of the crew were ill with pyrexia and headache. One of these, a boy, was able to walk about a little.	Cabins—All but two Forecastle—Yes Holds—One small one	None	Boats—One with about 2 ins. salt water Other vessels—None	None	—
s.s. "Nembe"	Forcados ... 2 days Burutu ... 5 days Lagos ... 21 days	White ... 22 Black ... 10 Krooboys 38	The assistant cook, a white boy, was taken ill at Burutu, and died in 5½ hours. Reported as Yellow Fever by the Port Authority, and the ship was quarantined and fumigated.	Cabins—All ... Forecastle—Yes Holds—Three	None	Boats None ... Other vessels None	None	—
s.s. "Henrietta Woermann"	Assinie ... 2 days Cape Palmas 1 day Sasstown ... 1 day Sinoe ... 1 day Grand Bassam 1 day Cape Mount 1 day Manoh ... 1 day Sulimah ... 1 day Monrovia ... 2 days Freetown ... 6 hours Sherbro ... 1½ days		None...	Cabins—One ... Forecastle—Yes Holds—None	1 1 None	Boats none examined Other vessels—None looked for	None	Only came into port to drop the pilot, so gave no time for a longer examination

LIST OF SHIPS EXAMINED *continued.*

Name of Ship.	Ports of Call and Time in Each.	Number of Crew.	Sickness during Voyage.	Parts of Vessels Examined.	Mosquitoes Found.	Receptacles containing Water.	Larvæ Found.	Remarks.
s.s. "Warri"	Sapele ... 4 days Koko ... 2 days Warri ... 2½ days Forcados ... 19 hours Addah ... 1½ days Accra ... 6 hours Winnebah ... 1 day Barracol ... 16 hours Appam ... 2 hours Saltpond ... 2 hours Cape Coast Castle ... 11 hours Secondi ... 6½ hours Axim ... 1½ days	White ... 23 Black ... 10 Krooboys 39	Two of the white crew were taken ill about Axim, one apparently malaria, the other due to heat. Both were getting well when I saw them.	Cabins Six ... Forecastle Partly Holds One and part of another	12 1 None	Boats Three contained a moderate amount of fresh water Other vessels—None	None	—
s.s "Boma"	Sapele ... 3 days Koko .. 2 days Warri ... 2 days Forcados ... 1 day Addah ... 1 day Accra ... 1 day Appam ... 1 day Winnebah ... 1 day Saltpond ... Few hours Cape Coast Castle ... 1 day Secondi ... 2 hours Axim ... 1 day	White ... 22 Black ... 10 Krooboys 42	Captain was ill at Axim with malaria, and a quarter-master at Freetown. The former was nearly well when I was on board. The latter had only just been taken ill.	Cabins—All but two Forecastle—Yes Holds—One	None	Boats None ... Other vessels—None	None	—

[*Enclosure* 2.]

THE MEDICAL OFFICER OF HEALTH TO THE SENIOR SANITARY OFFICER.

SIR,

In answer to your memorandum of 13th June, 1914, asking for a report on the presence, and when present, the degree of prevalence, of the *Stegomyia* mosquito in vessels other than steamers, I have the honour to report as follows the result of my investigations.

In this connexion vessels of every class which were lying in this port, other than ocean-going steamers, have been examined.

2. (*a*) Two steam launches which sail between Port Lokkoh and Freetown were each examined on two occasions but nothing was discovered.

(*b*) Two steam tugs which are used in the harbour for towing lighters, etc., were examined but nothing discovered.

(*c*) Three small schooners which sail from Freetown and Gambia, Great Scarcies, Kambia River, etc., were examined. In one, which had just come from Gambia, a specimen adult of *Pyretophorus costalis* was found in the cabin. In the other nothing was discovered.

(*d*) Boats which ply between the harbour and the shore.

(1) Those plying the Bay and in use. Twelve were examined. All contained salt water and nothing discovered.

(2) Those lying on the shore, not in actual use. Fifty were examined. Thirteen contained fresh water with mosquito larvæ. The larvæ were bred out and found as follows:—

Stegomyia fasciata, one; *Stegomyia sugens*, five; *Culex duttoni*, four; *Culex pipiens*, three.

(*e*) Lighters lying in the harbour and used for carrying cargo from ship to shore. Fourteen were examined. All were made of wood, contained salt water, with the exception of two, which were made of iron and contained fresh water with mosquito larvæ. These bred as follows:—

Culex pipiens, one; *Stegomyia sugens*, one. In none of these cases were larvæ numerous.

(*f*) Native boats sailing from Freetown and Bullom for market purposes, a distance of about twelve miles. Twenty of these were examined. All were found to contain salt water and nothing was discovered.

(*g*) Native canoes. (1) Those actually in use. Seven were examined and found to contain salt water. Nothing discovered. (2) Those not in use. Two lying on the beach were examined and found to contain fresh water with mosquito larvæ. *Stegomyia sugens* bred out in both cases.

(*h*) I also examined the s.s. "Fulani," which was ashore on "Carpenter Rock." Six specimens of *Pyretophorus costalis* were discovered. The vessel was lying about one mile from shore and in the direction of the prevailing wind. The probability is that the mosquitoes had been brought from ports lower down the coast.

I have, &c.,

WILLIAM ALLAN,
Medical Officer of Health.

GOLD COAST.

THE ACTING GOVERNOR TO THE SECRETARY OF STATE.

(Received 3rd July, 1914.)

Government House, Accra,
13th June, 1914.

SIR,

With reference to your despatch of the 16th of December last, regarding the conditions of the sea-borne traffic of the West African ports, with special reference to the circumstances favouring the introduction of Yellow Fever by this means, I have the honour to transmit to you, herewith, a copy of a letter from the Principal Medical Officer summarizing the reports received by him from the Medical Officers at the various ports on the Gold Coast.

I have, &c.,

W. C. F. ROBERTSON,
Acting Governor.

[*Enclosure.*]

Medical Department, Victoriaborg, Accra,
5th June, 1914.

SIR,

I have the honour to submit a report in accordance with the terms of the Secretary of State's despatch of 16th December, 1913.

The following ports in this Colony supplied the information which may be summarized as follows :—

Port.	Number of Steamers Inspected.	Result.	
Axim ...	15	Negative.	
Seccondee	Numerous	,,	
Elmina ...	6	,,	
Cape Coast	Numerous	,,	
Saltpond ...	,, ...	,,	
Winnebah	Nil return owing to pressure of work	—	
Accra ...	7	Negative.	
Addah ...	1 coasting steames (Lagos)	,,	
,, ...	1 ocean going cargo steamer (Lagos).	Positive.	*Stegomyia calopus*, no larvæ.
,, ...	2 bar steamers	,,	*Stegomyia calopus*, no larvæ.
,, ...	6 river launches	,,	*Stegomyia calopus*, no larvæ.
Quittah ...	Nil return owing to pressure of work	—	

Note.—No report from Half Assinie as there was no Medical Officer there owing to shortage of staff.

The ports are given in order from windward to leeward, *i.e.*, west to east.

The reports indicate that unused boats, canoes, and other craft breed *Stegomyia calopus* should they have collections of rain water in them.

Only one ocean-going cargo steamer, s.s. "Muraji" (Addah) had *Stegomyia calopus* on board, although no likely breeding places were discovered, so it must be presumed they were carried from some leeward port but not a Gold Coast one. It might be argued that she obtained them from the bar steamers at Addah where she was lying, but that idea may be dismissed, as these steamers

lie too far away from the ocean-going ones in Addah roads and to leeward.

It is admitted that in this Colony it is unlikely, and I go so far as to say impossible, for mosquitoes to get from shore to ship.

That mosquitoes are found on occasions on the homeward-bound mail and cargo steamers is pretty well known, and I can personally vouch for the fact, but it is not to be wondered at when it is taken into account when they lie in the Nigeria ports and often with branch steamers tied up alongside. The latter, in my long experience of Nigeria, almost invariably harbour mosquitoes, and not alone that, but I have actually found them breeding in large numbers on board.

I have, &c.,

F. G. HOPKINS,

Principal Medical Officer.

The Honourable
The Colonial Secretary,
Victoriaborg, Accra.

NIGERIA.

THE GOVERNOR-GENERAL TO THE SECRETARY OF STATE.

(Received 28th November, 1914.)

Government House, Nigeria,
7th November, 1914.

SIR,

With reference to your despatch of the 16th December, 1913, on the subject of information required by the Yellow Fever (West Africa) Commission in regard to the conditions of the sea-borne traffic of the West African ports, I have the honour to transmit herewith a copy of a report from the Director of the Medical and Sanitary Service, covering a letter from the Principal Medical Officer, Southern Provinces, containing extracts from reports by Medical Officers who have been stationed during the current year in the various ocean and river ports of the Southern Provinces.

I have, &c.,

F. D. LUGARD,

Governor-General.

[*Enclosure.*]

COLONIAL SECRETARY,

The number of river craft and canoes containing larvæ is much smaller than I anticipated; this is probably due to the recent examinations that have taken place on them. The Medical Officer, Bonny (Dr. Bailey), has had considerable experience of stern-wheelers when he was stationed at Forcados-Burutu, and I rather think his remarks apply to that period of his career. In any case, the present Medical Officer at Forcados-Burutu (Dr. Booth), finds a large percentage of river craft, presumably launches and stern-wheelers, with mosquitoes on board, but only two with larvæ.

The report omits one important particular throughout, and this is the length of time that elapsed between the arrival of an ocean ship and the examination. This omission nullifies to a great extent the value of the report in regard to sea-borne traffic. This investigation, however, reveals the important fact that mosquitoes are conveyed from one port to another, both by ocean steamships and river craft.

T. HOOD, D.M.S.S.

30th October, 1914.

Lagos, *15th October*, 1914.

SIR,

I have the honour to forward you the following information extracted from the various reports received from Medical Officers, in reference to the introduction of Yellow Fever by sea-borne traffic.

Epe.—The Medical Officer reports that the shipping of the port consists of canoes, which invariably contain some water on the bottom of the canoe under a grating of sticks. He states he has frequently examined this water, but has never found any larvæ therein.

Badagry.—The Medical Officer reports that Badagry is the principal trading centre on the lagoon between Lagos and Porto-Novo. He states the facilities for the introduction of Yellow Fever are numerous:—(1) Large trading canoes from Lagos, about twenty weekly; (2) the French mail launches, which run twice weekly between Lagos and Porto Novo, call at Badagry; (3) German branch steamers. The Medical Officer reports these branch boats and lighters are favourite haunts of *Stegomyiæ*.

Lagos.— The following are the figures supplied by Dr. Laurie for this port :—

	Inspected.	Larvæ.	Larvæ. Percentage.	Adults.
Steamships ...	436	—	—	18
Boats, barges .	549	23	4·1	—
Canoes	14,751	54	·36	—
		Stegomyia fasciata ...		15
		Culex decens ...		3

Aboh.— The Medical Officer reports that since the beginning of the year no vessels calling at Aboh have been at sea.

Forcados.—The Medical Officer reports that he examined thirty-seven ships ; seven of these ships had *Anopheles* and eight ships *Culicines*—no larvæ were found. These were all ocean-going steamers.

Burutu.—The Medical Officer at Burutu reports that out of eighty-six ships examined five contained *Anopheline*, nine *Stegomyia*, and fourteen *Culicine* mosquitoes ; on two ships only were larvæ found.

The above were all river craft.

Onitsha.—No larvæ have been found in any vessel in this station. The steamers are river boats. No ocean boats are plying, canoes are local, and no cases of Yellow Fever have been observed.

Sapele.—The Medical Officer has examined 391 of all craft ; on steamers neither mosquitoes nor larvæ were found ; *Stegomyia* mosquitoes were found on one steam launch and one lighter, and 82 canoes contained water with larvæ, 22 of which on breeding out proved to be *Stegomyia*. *Stegomyia* mosquitoes were caught on five other canoes.

Warri.—The Medical Officer reports that from 75 per cent. to 90 per cent. launches and steamers have mosquitoes, the degree of prevalence of *Stegomyia* being small, the larval stage being only found on river-going steamers and canoes. Warri being an inland port all the steamers and launches have been tied up at the various wharves getting there ; this probably accounts for the high percentage of mosquitoes found on board.

Degema.—Thirteen ocean-going steamships examined, no larvæ found, but three contained mosquitoes, two of these vessels having *Stegomyia*. Of 57 steam launches and river steamers larvæ were found on three, which, on hatching out, proved to be *Stegomyia* ;

on 27 of these vessels mosquitoes were observed, mostly *Stegomyia* Of 1,450 trading and carrying canoes very few contained larvæ, and in all cases these were found in pots used for storing water; on hatching they were *Stegomyia*.

Bonny.—The Medical Officer reports main line steamers free. Branch boats have a few mosquitoes, larvæ found once in twenty examinations. Stern-wheelers without exception harbour *Stegomyia* mosquitoes in large numbers. He is of opinion that from a breeding and distributing point of view stern-wheelers are probably the most important vessels in the country.

Brass-Akassa.—The Medical Officer has furnished a nil report.

Calabar.—No larvæ on steamers, some adult mosquitoes, no *Stegomyia*. In launches no larvæ, but a few adult *Stegomyia*. Of 73 lighters inspected four had larvæ, mostly *Culex*, with a few *Stegomyia*. 1,113 canoes were inspected, ten had larvæ, chiefly *Culex*.

I have, &c.,

H. B. S. MONTGOMERY,

for Principal Medical Officer.

REPORT ON THE EXAMINATION OF HUMAN BLOOD IN ENGLAND FOR THE PRESENCE OR ABSENCE OF "SEIDELIN BODIES"

(*Paraplasma flavigenum*, the so-called Parasite of Yellow Fever).

BY

JOHN WESTRAY CROPPER, M.B., C.H.B., M.SC. (LPOOL.).

(*The John Howard McFadden Researches, The Lister Institute of Preventive Medicine.*)

At the request of the Yellow Fever (West Africa) Commission I have examined the blood of a number of persons resident in England for the presence or absence of "Seidelin bodies." None of these persons had been exposed to yellow fever, and with a few exceptions they had not been out of England. The persons examined included a large proportion of children, and the majority of them, both adults and children, suffered from anæmia. The examination was made owing to some doubt having been thrown on the nature of the bodies described by Seidelin, from the fact that they had been found in the blood of persons who were not supposed to be suffering from yellow fever, and also from their discovery in the blood of various animals, particularly young ones.

The bodies discovered by Seidelin in the red blood corpuscles of yellow fever patients exhibit a variety of appearances, which depend to some extent on the stage of the life-cycle which the "parasite" has reached. The characteristic appearance which has guided me in the search for these bodies was the association together, in the corpuscle, of a scarlet staining dot and a bluish-grey area which may assume many different shapes. It was considered advisable to find bodies which leave no room for doubt as to their identity with the "Seidelin bodies."

Technique.—The blood was in all cases taken from the finger with a sterile needle and was transferred to a clean slide by means of a cigarette paper. The film thus obtained was dried by waving in the air, and was fixed in pure methyl alcohol for about an hour. It was then stained in eosin-azur solution for 24 hours, washed in tap water, blotted dry, and mounted in canada balsam, cedar oil or parolein. The solution of stain was made by dissolving one eosin-azur soloid (Burroughs, Wellcome & Co.) in 10 cc. pure methyl alcohol and diluting this to the proportion of 1–20 with faintly alkaline distilled

water. When properly stained to demonstrate "Seidelin bodies" the red corpuscles appear a homogenous dark pink colour, the nuclei of the leucocytes being deep purple and their granules scarlet. It is important to attend to these details when searching for the bodies in such scanty numbers as I have found, otherwise they may be missed altogether. Each film requires from one to two hours' examination to observe every red corpuscle.

Results of Examination.—In 284 blood films from 102 persons, 68 of whom suffered from anæmia, I have been able to find five bodies (Plate 1) similar in appearance to those described by Seidelin in the blood of yellow fever patients. Two of the bodies occurred in a child of three years of age, and the remaining three in children aged two, three, and ten respectively. None of these cases had been exposed to yellow fever, but all of them suffered from anæmia. In addition to these about a dozen bodies were seen which, owing to their minute size and difficulty of distinction from artefacts, have been discarded as doubtful. In three other cases the scarlet dot was found in the corpuscle without the blue area, and in one case the blue staining portion was alone (Plate I., No. 7). None of the bodies have been seen free in the blood. Several films of fœtal blood were taken from the umbilical cord immediately after birth but were unfortunately spoiled.

The cases examined are given in detail in the Tables I. to III., and the most typical bodies found are shown in the accompanying coloured plate.

I have been unable to distinguish the bodies which I have found in human blood in England from those in the original preparations of Seidelin (some of which I have seen), and from the coloured drawings of *Paraplasma*-like bodies in papers by Macfie & Johnston and Wenyon & Low.

I have no opinion to offer as to the nature of the bodies. Various writers have already suggested their connection either with the development of, or with degenerative changes in, the red corpuscles. I do not feel justified, from the small number of positive cases, in stating that the bodies are due to anæmia, as several very anæmic patients gave negative results. The finding of the bodies in such small numbers is so difficult that they may have been missed in these cases. The bodies were also apparently absent in three cases with nucleated red corpuscles, and in three cases with a leucocytosis.

TABLE I.

PERSONS SUFFERING FROM ANÆMIA: ADULTS, AND CHILDREN ABOVE FIVE YEARS.

No.	Sex.	Age.	Remarks.	Number of films examined.	"Seidelin bodies."
1	M	19	—	2	Nil.
2	M	15	After diphtheria	4	Nil.
3	M	18	After scarlatina	3	Nil.
4	M	21	After pneumonia	2	Three doubtful bodies.
5	M	15	—	2	Nil.
6	M	30	Leucocytosis	2	Nil.
7	M	34	—	2	Nil.
8	M	18	After scarlatina	2	Nil.
9	F	13	After diphtheria	2	Nil.
10	M	27	—	2	Nil.
11	M	20	After influenza	4	Two doubtful bodies.
12	F	18	Chlorosis	4	Nil.
13	F	15	Chlorosis	2	Nil.
14	F	13	Chlorosis	2	Nil.
15	F	12	After diphtheria	2	Nil.
16	F	10	Severe anæmia	4	Nil.
17	F	16	Severe anæmia	4	Nil.
18	M	13	—	2	Nil.
19	F	6	—	2	Nil.
20	M	40	Malaria 10 years ago	4	Several doubtful bodies.
21	F	8	Slight anæmia	2	Nil.
22	F	10	Lymphocytosis	2	Nil.
23	F	20	Cystitis	2	Nil.
24	M	23	—	2	Several doubtful bodies.
25	M	5	—	2	Nil.
26	M	8	—	4	Nil.
27	M	10	—	4	Nil.
28	F	12	A few nucleated erythrocytes	3	Nil.
29	F	10	—	2	Nil.
30	F	14	—	2	Nil.
31	F	10	After appendicitis	3	One ring-shaped body.

TABLE I.—continued.

No.	Sex.	Age.	Remarks.	Number of films examined.	"Seidelin bodies."
32	F	12	—	2	Nil.
33	F	6	—	3	Nil.
34	M	5	—	2	One doubtful body.
35	M	6	Severe anæmia	4	Nil.
36	F	5	—	2	Nil.
37	F	8	Slight anæmia	2	Nil.
38	M	6	—	1	Nil.
39	M	10	After diphtheria	2	Nil.
40	M	12	Slight anæmia	1	Nil.
41	F	6	—	2	Nil.
42	M	10	—	2	Nil.
43	F	14	Slight anæmia	2	Nil.
44	M	12	—	2	Nil.
45	M	10	—	2	Nil.
46	M	7	After scarlatina	4	Nil.
47	M	6	—	4	Nil.

TABLE II.

PERSONS SUFFERING FROM ANÆMIA: CHILDREN UNDER FIVE YEARS.

No.	Sex.	Age.	Remarks.	Number of films examined.	"Seidelin bodies."
1	M	4	Marked anæmia	4	Nil.
2	F	4	Slight anæmia	4	Nil.
3	M	4	Tabes, marked anæmia	4	Nil.
4	M	2	Several nucleated erythrocytes	4	Nil.
5	F	2	—	4	One linear-shaped body.
6	F	5	—	4	Nil.
7	M	4	—	4	Nil.
8	F	3	Slight anæmia	2	Nil.
9	M	2	—	4	Nil.
10	M	3	Slight anæmia	2	Nil.
11	M	3	A few nucleated erythrocytes	3	Nil.
12	F	3	—	3	Two bodies found.
13	M	2	—	3	Nil.
14	F	3	After diphtheria	3	Nil.
15	M	3	Slight anæmia	4	One irregular-shaped body.
16	M	4	—	3	Nil.
17	F	3	Severe anæmia	4	Nil.
18	F	3	—	4	Nil.
19	M	4	After influenza	4	Nil.
20	M	3	—	4	Nil.
21	M	4	After diphtheria	4	Nil.

TABLE III.

PERSONS WHO WERE NOT ANÆMIC: ADULTS AND CHILDREN.

No.	Sex.	Age.	Remarks.	Number of films examined.	"Seidelin bodies."
1	M	38	Enteritis, lymphocytosis	2	Nil. Nil.
2	F	16	Healthy	2	Nil.
3	F	36	Healthy	2	Nil.
4	M	10	Hæmophilia	2	Nil.
5	M	7	Bronchitis	2	Nil.
6	M	12	Measles	2	Nil.
7	F	14	Nephritis	2	Nil.
8	M	18	Rheumatic fever	2	Nil.
9	M	6	Healthy	2	Nil.
10	F	8	Measles	2	Nil.
11	M	12	Influenza	3	Nil.
12	M	16	Phthisis	4	Nil.
13	F	12	Healthy	4	Nil.
14	M	11	Healthy	4	Nil.
15	M	6	Healthy	3	Nil.
16	M	8	Measles	2	Nil.
17	F	5	Healthy	4	Nil.
18	F	5	Healthy	4	Nil.
19	F	22	Plumbism	2	Nil.
20	M	28	Tonsillitis	2	Nil.
21	M	30	Epilepsy	1	Nil.
22	M	28	Diabetes	2	Nil.
23	M	18	Jaundice	3	Nil.
24	F	14	Tonsillitis	2	Nil.
25	F	3	Healthy	2	Nil.
26	F	4	Healthy	4	Nil.
27	M	5	Healthy	4	Nil.
28	F	42	Diabetes	4	Nil.
29	M	14	Pneumonia	4	Nil.
30	F	3	Healthy	2	Nil.
31	F	5	Healthy	2	Nil.
32	F	2	Rickets	3	Nil.
33	F	5	Healthy	2	Nil.
34	M	10	Diphtheria	4	Nil.

PLATE I.

Bodies resembling "Seidelin bodies" found in the blood of persons in England who had not been exposed to Yellow Fever.

Nos. 1–5. Typical bodies.

No. 1. Scarlet dot and irregular-shaped body.
„ 2. Scarlet dot and semi-circular blue body.
„ 3. Scarlet dot and Y-shaped blue body.
„ 4. Scarlet dot and linear blue body.
„ 5. Scarlet dot and ring-shaped blue body.
„ 6. Scarlet dot only.
„ 7. Two linear blue bodies only.

All figures drawn direct from the microscope with the camera lucida.

NOTES ON THE REARING OF *STEGOMYIA FASCIATA* IN LONDON.

By Malcolm Evan MacGregor.

(*Wellcome Bureau of Scientific Research.*)

(*Reprinted from "Journal of Tropical Medicine and Hygiene," Sept. 1st, 1915.*)

In May of this year the Bureau was presented by Sir James Kingston Fowler, Chairman of the Yellow Fever Commission, with a few dried leaves of the West African cottonwood tree, on which were eggs of *Stegomyia fasciata*, these having been sent to the Colonial Office by Mr. A. W. Bacot from West Africa (Sierra Leone).

The leaves had been a fortnight in transit and had remained at the Colonial Office for three months, being thus, at the very least, three-and-a-half months in a dried condition ere they reached my hands, while from what I hear they may very probably have been dried for a considerably longer period. These leaves were packed between grease-proof paper in a small cardboard box, and were in a thoroughly desiccated state.

On examination under the binocular microscope I found a fairly large number of eggs adhering to the leaves, for the most part secured by a fine deposit of dried mud.

About 75 per cent. of the eggs were apparently dried up, with their shells crinkled and shrivelled, while the rest looked normal. I therefore examined specimens of both by breaking them open with needles, and found them to contain moisture and partly formed larvæ.

The leaves were then cut up into pieces about 1 in. square and placed on tap water in glass containers and kept at the temperature of the Laboratory (18° C.). This was done at 11.30 a.m. on April 29, and by 9.30 a.m. the next day the water was crowded with larvæ that had hatched out in such numbers as to leave me in no doubt that the shrivelled eggs, as well as the normal, had been viable.

Larval Food Supply.

This first generation of larvæ was divided into approximately equal numbers and placed in separate containers: No. 1 containing tap water contaminated with straws from horse manure and the organic matter and bacteria thereon; No. 2 containing fresh water from the Serpentine Lake in Hyde Park. Both containers were then placed under equal conditions of light and temperature. Four days later the larvæ in container No. 1 had grown and greatly increased in size, while those in container No. 2 appeared to have hardly grown at all, and were moreover sluggish in their movements compared with the former. The waters of both containers, together with the respective larvæ, were therefore then mixed and more straws from the horse manure added.

Optimum Temperature with given Food Supply.

To determine the optimum temperature with the above food supply for rearing the larvæ in the Laboratory, eight lots of twenty larvæ, of as nearly as possible one size, were placed in eight small beakers, together with equal supplies of water from the main container.

These beakers were arranged along a copper sheet, heated by a small Bunsen flame at one end, at varying distances from the heated end, and when the temperature of the water in each beaker had become constant, it stood as follows:—

No. 1. 16° C.	No. 4. 25·9° C.	No. 7. 37° C.
No. 2. 19·5° C.	No. 5. 30·8° C.	No. 8. 41·4° C.
No. 3. 23·8 C.	No. 6. 35·2 C.	

From the beakers at the higher temperature evaporation was somewhat rapid, but was compensated for by the addition of tap water in order to keep the concentration of the food supply also constant. This, obviously, would not have been the case if water from the main container had been used.

In order to avoid a somewhat unwieldly table, giving dates of pupation and emergence of first imagos, &c., the results may be briefly stated as follows.

In beaker No. 4 (temperature 25·9° C.) the larvæ seemed to do best, and the mosquitoes which bred out from this beaker were certainly the largest and strongest specimens. In No. 3 (temperature 23·8° C.) the imagos, when they emerged, were perhaps equally

fine specimens, but they were, as an average, three days longer in the complete metamorphosis. At temperatures below this the number of days for the metamorphosis was considerably prolonged. In beaker No. 1 one or two of the larvæ died, and the imagos on emergence were undersized and somewhat feeble. At the higher temperatures, that is, in beakers Nos. 5, 6, and 7, the average date of emergence of the imagos was several days in advance of those in beaker No. 4, and the specimens were very much undersized, though all were active and apparently healthy. The larvæ in beaker No. 8 (temperature 41·4° C.) all died within a day.

Thus it will be seen that with the food supply and the light conditions used the optimum temperature was from 23° to 26° C., and this has been the temperature adopted for the subsequent generations. At this temperature, and with this food supply, the average larval period was ten days, and the average pupal period six.

Males and Females.

On emergence the male and female mosquitoes were transferred to a small cage consisting of a wooden box that had had top and bottom removed and screened with butter muslin. It was observed that copulation took place almost as soon as the mosquitoes were able to fly, and before any food had been given to them. The mating took place usually in mid-air, and the female was fertilized as the pair flew slowly about, or, as more often happened, the female immediately settled on the muslin or sides of the cage, and copulation took place there, the male being in a peculiar position with his back and wings pressed against the support on which the female rested, with the abdomen arched upwards.

It was found that the mosquitoes would readily feed on a black guinea-pig, and this has furnished the food supply for the adult females. A black guinea-pig was used becaused a marked preference was noticed in the mosquitoes for this colour. At one time a white animal was substituted, and the mosquitoes could not be induced to attack it at all readily, even when the hair on the back was shaved; while the one or two that settled and commenced to feed were instantly disturbed by the slightest movement on the guinea-pig's part, and would fly off to the far ends of the cage and remain there.

When the white guinea-pig was removed and a black one put in, the mosquitoes attacked it vigorously, and no amount of persistent endeavour to drive them off that the guinea-pig indulged in was successful. I have noticed partially gorged mosquitoes sitting on the black animal's head, apparently quite oblivious of the most violent head-shaking.

It was also noticed that the mosquitoes, before they had partaken of their first meal of blood, did not attack the guinea-pig in the voracious manner they adopted at subsequent meals, when, as it were, they had "tasted blood."

Length of Life in Males and Females.

Under the conditions that the mosquitoes live at the laboratories it has been found that as an average the males live from ten days to three weeks, while the females live from a month to six weeks, while some are alive still after two-and-a-half months.

Feeding Habits of Female and Oviposition.

An average specimen female will become completely engorged with blood in from three to five minutes, and when replete is so heavy that she can barely fly, and usually prefers to hop off the guinea-pig on to the floor of the cage, and crawl up the sides, taking refuge in the darkest place she can find.

The eggs in the ovaries would seem to require from three to five days in which to become mature after the blood meal, and oviposition was found to have taken place in all cases within this period.

When all the mosquitoes have fed that are inclined to do so, it has been the custom to remove the guinea-pig from the cage and place therein a small Petri dish partially filled with tap water, or the water used in rearing the larvæ, with a few small leaves floating on the surface.

The eggs are deposited for the most part directly on the surface of the water, but many are also attached to the leaves it is found. In neither case, however, are they laid with much attempt at system, and the best that can be said is that they tend to be deposited in irregular clusters. Apparently the eggs must not be submerged for any length of time before they hatch, and it has been found

that water with eggs floating on the surface, when poured from one vessel to another (and the eggs therefore thoroughly wetted), causes the eggs to sink to the bottom and very few larvæ then hatch out.

Individual females have made as many as eight separate ovipositions, and will feed again readily within a day after laying each batch of eggs.

Males.

Careful study of the habits of the male over the period of its life within the cages convinces me that while it does not suck blood as the female does, yet it is very fond of occasionally working its proboscis over the guinea-pig's skin and appears to draw up minute quantities of sweat and saliva from a "licked" part. Males are often also seen resting on the water in the Petri dishes, with the tip of the proboscis submerged, and apparently drinking.

The males are most active in the afternoons, and seem ever ready to mate with females on the wing, but in no instance has it been observed that a male will approach a *resting* female. If the sides of the cage are knocked and the resting mosquitoes made to take to the air, the males immediately unite with the female mosquitoes and copulation may take place while they are both on the wing, or the female will alight and the male be driven against the cage in the peculiar attitude that I have described elsewhere in this paper.

When the guinea-pig is in the cage the males show a marked preference to sitting on it rather than on the sides of the cage, and seem to choose the tips of the ears as a favourite resting place. They will sit there if not disturbed for an hour or more, with the plumes and antennæ at times in rapid vibration.

The Pupæ.

The pupal condition is usually attained during the night, but if the larvæ are kept in a fairly dark place this change can be observed. The fully grown larva, which is about to pupate, can be distinguished by its becoming almost opaque, and of a yellowish white colour except for the head; the usual dark line in the larvæ that marks the alimentary tract having disappeared. On pupation the larval skin splits open on the dorsal side of the thorax, and

with much wriggling the pupa struggles out. This manœuvre is often accomplished at the bottom of the tank, and the withdrawing of the "tail" end seems to occasion the most difficulty, but the change is completed very rapidly indeed—often within 30 secs. When the pupa first emerges it is of the same yellowish-white colour, but in the course of a few hours becomes darker, and the colour of the pupa is a fair indication of the stage it has reached before the emergence of the adult.

The Larvæ.

When first hatched they are about 1 mm. long and 0·3 mm. at greatest breadth, quite white, and rather difficult to see if the container is not placed on a black background. The larvæ grow very rapidly, and in a few hours at a temperature of 25° C. are much larger and more conspicuous by the head having enlarged, and become dark in colour.

For some time it was customary to give the larvæ the food furnished by simply adding a few straws from horse manure to the water; but, as one would naturally expect, the quantity of food furnished by this means was uncertain, and while it amply sufficed for their needs in some instances, it was insufficient in others. By accident a pellet of the guinea-pig's fæces was added one day, and the larvæ were seen to feed greedily upon it, even in the presence of an abundant supply of other food, and since then guinea-pig's fæces have been regularly added to the water, the larvæ thriving splendidly in consequence.

With the water from the Serpentine Lake that was used in the first experiment, one or two cyclops were introduced, and in the subsequent mixing of the waters descendants have been introduced into all the containers. They do not, however, seem to interfere with the larvæ, nor do the latter appear to attack the cyclops. Nevertheless, that the larvæ like animal food can be demonstrated by adding newly hatched larvæ to the same container that holds well-grown individuals, the young larvæ, even if added in large numbers, being speedily consumed by the others.

It is common knowledge that the larvæ of mosquitoes very readily react to light, and that the larvæ of *Stegomyia* avoid it and seek the darker places in which to live, except if forced into light

when they come to surface to breathe. Mitchell* has recorded the fact that some mosquito larvæ also react to what appears to be a sense of smell, and though I have not seen it recorded elsewhere, I find that *Stegomyia* larvæ apparently react to sound as well. It was noticed that whenever a mercury break, that is attached to an X-ray apparatus in my laboratory, was switched on, the larvæ immediately dived to the botton of their containers when the high-pitched note that the mercury break emits commenced. The X-ray apparatus and the containers are separated by the length of the laboratory, and are some considerable distance apart, so that it is not due to simple vibration. Thinking that the container might resonate with the note of the break, the larvæ and water were transferred to another vessel possessing a totally different vibration period to the first. However, as before, the larvæ would immediately dive when the note of the break sounded. It was also found that a sharp whistle would make them react in the same way.

Until fully grown the larvæ of *Stegomyia* are semi-transparent in parts of their bodies, but when about to pupate they cease to feed, and most of the food in the alimentary tract is either digested and absorbed, or excreted, and the larvæ become more opaque and of a yellowish colour, so that individuals about to pupate can be readily distinguished.

The Eggs.

These have been laid in very large numbers about three to five days after the females have fed, and kept at a temperature of 30° C. (which has been found to be the optimum for the development of the eggs under the existing conditions) they have hatched in an average from three to five days. The variation in individual eggs from the same batch in the incubation period is remarkable, however, some being several days longer in hatching than the rest, and in many cases eggs laid at one time by the same female and kept under precisely uniform conditions will hatch out irregularly over a period as long as ten days or a fortnight, for some reason I have not yet been able to determine. It may possibly be a protective provision in Nature to guard against the chance of all the larvæ hatching before a rain or other pool has become established.

* "Mosquito Life." By E. G. Mitchell (1907).

Remarks.

Although the rearing of *Stegomyia*, after the eggs have been desiccated and sent through the post, has been accomplished before by several observers, notably by Theobald, Newstead, Francis, Peryassu, and others,* yet, as far as I can determine, the present investigations at the Bureau have succeeded in producing the greatest number of subsequent generations from such eggs, the sixth generation now having been established among my mosquitoes. There has been no loss in the size or vitality of the insects, and it is now hoped that with the apparatus that has been constructed and fitted up in the Museum of the Bureau that a permanent exhibit of the life-history of *Stegomyia fasciata* has been set up for observation by anyone interested in the subject.† Similar apparatus is also to be used in an attempt to rear *Anophelines* and *Culex pipiens* in the same way for comparative purposes.

It had been hoped that experiments might have been undertaken in comparative temperature, experiments, &c., between *Stegomyia fasciata* larvæ and those of *Culex pipiens*, since in the course of my work I was called upon to determine the species of a mosquito that was found breeding in a "sump" pit at the Highgate Station of the Underground Railway, and which turned out to be the latter insect.

These insects were breeding in enormous numbers and situated in the "sump" pit were at a distance of 120 ft. below the ground. The conditions were so extraordinary that I hope to write a brief note on the subject for separate publication. I was thus enabled, however, to obtain large numbers of larvæ with which I intended to conduct the above-mentioned comparative studies, but they unfortunately speedily died in my laboratory, due, I think, to the fact that they had lived in complete darkness beforehand and could not tolerate the conditions I transferred them to.

Recently, nevertheless, I have obtained large numbers of larvæ of the same mosquito from a different source, and these are living well, so that I hope to be able to conduct the experiments in mind shortly.

It is particularly interesting to record the fact that Dr. A. C. Stevenson, of this Bureau, while engaged in searching for endo-

* See "A Text-book of Medical Entomology," by Patton and Cragg.

† Since these Notes were first published in the "Journal of Tropical Medicine and Hygiene" other four months have elapsed, with several successive generations, and the mosquitoes are still (January, 1916) as vigorous as ever.

parasites in the *Stegomyia* larvæ, discovered a very large percentage to be infected with *Lankesteria culicis*. This parasite was first described by Ross in 1898, when he found it in *Anophelines* in India, and was subsequently found by others, and by Wenyon in *Stegomyia fasciata* larvæ in Bagdad. The parasite has been particularly carefully studied and described by the latter investigator,* and a record of the discovery of the parasite in the larvæ I have been working with from West Africa is to be published by him elsewhere. ("Journal of Tropical Medicine and Hygiene," September 1st, 1915.)

By the demonstration once more of the remarkable resistance of the eggs of *S. fasciata* to desiccation, attention is called again to the fact of what this may very easily mean in the distribution of this mosquito, and hence its bearing in the spread of yellow fever.

It is clearly conceivable that dried leaves with eggs attached might, by wind alone, be spread over immense distances, while by export of raw materials in bales of all sorts, dried leaves with the eggs adhering could be very well distributed to the ends of the earth. Moreover, the hardiness of *S. fasciata* would permit of its establishing itself in many places where it is not found to-day, and with the vector of yellow fever present, the living virus—if such it prove to be—need only be introduced into the infested area for the danger of an epidemic to be made manifest.

SHORT LIST OF LITERATURE WHICH DEALS WITH MOSQUITO LIFE-HISTORIES.

BERKELEY, W. N. (1902). "Laboratory work with Mosquitoes."

GILES, G. M. (1902). "Gnats or Mosquitoes, including a Revision of the *Anophelines*."

GOELDI, E. A. (1905). "Os Mosquitoes no Para."

HOWARD, L. O. (1901). "Mosquitoes."

HOWARD, DYER and KNAB (1912). "The Mosquitoes of North and Central America and the West Indies."

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MITCHELL, E. G. (1907). "Mosquito Life."

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ROSS, R. (1900). "Malaria and Mosquitoes."

SMITH, J. B. (1904). "Report of New Jersey State Agricultural Experimental Station on Mosquitoes."

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* "Parasitology," Vol. IV, 1911.

SOME OBSERVATIONS ON FEVERS INVESTIGATED IN QUITTAH, MARCH TO JUNE, 1914.

By G. E. H. Le Fanu, M.B., C.M. (Aberdeen), D.T.M. (Liverpool);
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Pending the arrival of a laboratory outfit, some preliminary work was done from March to June, 1914, and the results are attached. These are necessarily incomplete. Attention was given chiefly to children, and here the attempts to obtain material and continuous observation generally met with insurmountable difficulties.

At the very end of June the laboratory outfit arrived, but this work was unavoidably interrupted towards the end of July.

The cases number 106, 81 children and 25 adults from 17 years upwards. The following diseases occurred amongst them:—

Malaria	94 (worm infections in 11)
Yellow Fever	3
Helminthiasis	4
? Enteritis	1
Typhoid Fever... ...	2 (1 doubtful)
Pulmonary Congestion...	1
Undiagnosed	1

Malarial parasites were found in 88 of the cases diagnosed as Malaria:—

Subtertian	in	55
Tertian	,,	19
Quartan	,,	2
Subtertian and tertian ...	,,	4
Tertian and Quartan ...	,,	2
Quartan and *plasmodium tenue*	,,	1*
Species not determined ...	,,	5

* An account of this specimen was published by Prof. Stephens in the "Annals of Tropical Medicine and Parasitology," Vol. IX., No. 1, of 18th March, 1915.

Some data regarding the occurrence of albuminuria and jaundice are embodied in Table I. Albuminuria was found in a number of children under 2 years of age, the youngest only 8 months old.

Three cases of Yellow Fever were observed. In one (No. 26), which was fatal, there could be no doubt as to the diagnosis. In the second (Case 63) there seems to have been a latent malarial infection, as careful examination of the thick films repeatedly revealed the presence of pigment, though no parasites were found until the 8th day. The third case (No. 98) was slight and of short duration.

In the two cases of typhoid fever, the bacterial infection could not be determined, as the means to carry out the necessary tests and cultures did not exist. In the second case bacilluria was observed.

Bodies which seemed identical with *paraplasma* were repeatedly noticed, and ringed specimens from Cases 90, 96, 98 and 99 were forwarded (with letter of 25th June, 1914).

Table II. shows the results of examinations of fæces for ova, &c., carried out at Quittah and Lome. In 47 out of the total of 244, ankylostome infection was found. This is a very low percentage, and is probably explained by the majority of the cases examined being town dwellers, and therefore living in more satisfactory hygienic surroundings than the population of the "bush." About 50 per cent. of the cases showed definite symptoms of ankylostomiasis. Of these 8 died (2 at Quittah and 6 in Lome). The disease was confirmed postmortem in one case.

TABLE I.

LIST OF CASES WITH ALBUMINURIA AND JAUNDICE

(Fever Cases, Quittah—March to June, 1914.)

Case Number.	Sex.	Age.	Albuminuria.	Jaundice.	Worms.	Malaria.	Yellow Fever.	Typhoid.	Undiagnosed.	Remarks.
1	M	41½	††	*	?	§	—	—		—
11	F	7	†	†	?	§	—	—	—	
13	M	12	†	*	*Ascaris l.*	*	—	—		—
17	M	Adult	†	*	?	§		—	—	? Gonorrhœa
26	F	28	†††	†††	*Ascaris l.* (post mortem)	*		—	—	Died
30	M	1	†	*	?	§	-	—	-	-
37	M	6	†††	*	*Ascaris l.*	§	—	—	—	—
38	M	5	†	*	*Ascaris l.*	§	—	—	—	—
41	F	1½	†	*	?	§	—	—	—	—
42	F	10	†	*	?	§		—	—	—
46	M	12	††	††	*Ascaris l.*	§		-	—	—
47	M	2	††	*	*	§	—	—	—	Died
48	M	4	*	†	?	§	—	—	—	—
49	F	23	†	†	*Rhabdonema*	§		—	—	—
50	M	12	†	*	?	§		—	—	—
53	F	6	†	*	*Ascaris l.* ... *S. hæmatobium*	§		—	—	—
59	M	25	†††	*	*Ankylostomum d.* ...	*		—	-	Ankylostomiasis
60	F	1½	†	*	?	§	-	—	-	—
62	M	1½	†	*	?	§	—	—	—	—
63	M	26	†††	††	*Ascaris l.* and *Ankylostomum d.*	*	§	—	—	—
66	F	5	†	*	?	§	—	—	—	

† Slight.
†† Marked.
††† Very marked.

? Not examined.
* Absent.
§ Present.

TABLE I.—continued.

Case Number.	Sex.	Age.	Albuminuria.	Jaundice.	Worms.	Malaria.	Yellow Fever.	Typhoid.	Undiagnosed.	Remarks.
71	M	5	†	*	?	§	—	—	—	—
74	F	16	††	*	?	§	—	—		-
75	F	1½	†	*	?	§	—	—	—	—
76	F	6	†	*	?	§	—	—	—	
83	M	6	†	*	?	§	—	—	—	—
84	M	26	††	*	*Rhabdonema*	*	-	—	—	Pulmonary congestion
85	F	28	*	†	*Trichocephalus tr.* ...	§	-	—	—	—
90	M	45	††	*	*Ascaris l.* and *Trichocephalus tr.*	*		§	—	—
92	M	18	†	*	?	§	—	—	—	—
96	M	22	†††	*	*Trichocephalus tr.* ...	*	- -	-	—	Pulmonary congestion
98	M	26	†	†	*Ascaris l.*	*	§	—	—	—
99	M	17	†	†	?	*	—	—	§	—
100	M	1½	†	*	?	§	—	—	-	—
101	F	17	†	*	*	§	—	§	-	-
104	F	6	†	*	?	§	—	- -	—	—
106	F	2	†	*	*Ascaris l.*	§	—		—	—
TOTALS ... 37	37		35	9	15	28	3	2	1	—

† Slight.
†† Marked.
††† Very marked.
? Not examined.
* Absent.
§ Present.

TABLE VII.

TABLE SHOWING INFECTION WITH INTESTINAL WORMS, &c., IN QUITTAH AND LOME.

Parasites.	Quittah.	Lome.	Total.
Ascaris l.	39	28	67
Ankylostomum and *Necator*	11	34	45
Trichocephalus tr.	5	2	7
Oxyaris verm.	—	1	1
Rhabdonema	2	1	3
Schistosomum m.	1	2	3
Bilharzia tr.	—	3	3
Tænia (sp. undetermined)	—	7	7
Ankylostome and *Ascaris*	9	19	28
Ankylostome, *Ascaris* and *Trichocephalus*... ...	5	3	8
Ankylostome, *Ascaris*, *Trichocephalus* and *Rhabdonema*	1	—	1
Ankylostome, *Ascaris* and *Rhabdonema*	2	2	4
Ankylostome and *Trichocephalus*	4	1	5
Ankylostome and *Rhabdonema*	1	3	4
Ankylostome, *Ascaris* and *Schistosomum m.* ...	1	—	1
Ascaris and *Trichocephalus*	7	2	9
Ascaris, *Trichocephalus* and *Rhabdonema* ...	1	—	1
Ascaris and *Schistosomum*...	2	—	2
Rhabdonema and *Schistosomum*	—	1	1
Negative	23	21	44
TOTALS	114	130	244

FEVER CASES, QUITTAH,

No.	Date.	Tribe, &c.	Age.	Sex.	Temperature at Time of taking Film.	Quinine.	Clinical Symptoms.	Parasites.
44	4.5.14	Alduna	1	M.	T. 101°F. P. 152	None	Fever ... ... Vomiting Convulsions Anæmia	Present ... ? species Pigmented mononuclears
45	4.5.14	Alduna	2	M.	T. 100°F. P. 128	None	Fever ... ... Cough Diarrhœa Splenic enlargement	Subtertian ... Pigmented mononuclears
46	11.5.14	Alduna	12	M.	T. 98·6°F. P. 78 E.T. 99·2° P. 74	None	Jaundice ... ... Frontal headache Epigastric pains Albuminuria	Subtertian ... Pigmented leucocytes
47	11.5.14	Alduna	2	M.	T. 101·4°F. P. 164	None	Fever ... ... Splenic enlargement Vomiting Severe anæmia Albuminuria	None ... Pigmented mononuclears
48	11.5.14	Alduna	4	M.	T. 101·2°F. P. 104	None	Fever ... ... Anæmia Vomiting Jaundice	Subtertian ... Pigmented mononuclears
49	12.5.14	Alduna	23	F.	T. 100°F. P. 104	None	Fever ... ... Pain in legs and back Frontal headache Splenic enlargement Anæmia (Tallquist 50%) Bilious vomit, 15.5.14 Albuminuria	Subtertian ...
50	12.5.14	Alduna	12	M.	T. 100·4°F. P. 72	None	Fever ... ... Pain back and legs Frontal headache Albuminuria	Quartan ...
51	13.5.14	Syrian	4	M.	T. 103°F. P. 130	None	Fever, 1 day	Tertian and subtertian Pigmented mononuclears
52	14.5.14	Alduna	21	M.	T. 99·6° F. P. 72	None	Fever ... ... Frontal headache Pain in back and legs Splenic enlargement	Subtertian ...
53	18.5.14	Alduna	6	F.	T. 102·6° F. P. 112	None	Fever ... ... Splenic enlargement Albuminuria	Subtertian ... Pigmented mononuclears

MAY AND JUNE, 1914.

Albuminuria.	Jaundice.	Cause of Jaundice.	Fever.	Cause of Fever.	Ova in Stools.	Diagnosis.	Remarks.
Urine not obtainable	None	—	Present	Malaria	None ... ... *E. hystolitica*	Malaria .. Complicated later on with Amœbic Dysentery	Died 15.5.14
Urine not obtainable	None	—	Present	Malaria	--	Malaria ...	Recovery
Present (marked opacity) up to 13.5.14 Bile pigment on 13th and 15th	Marked	? Helminthic (Ascarids)	Slight	Malaria	*Ascaris l.* ...	Malaria with Ascariasis	Recovery
Present (opacity)	None	—	Present	Malaria	None found ..	Malaria ...	Died 14.5.14
None ... ... Compound Protein	Slight on 14.5.14	?	Present	Malaria	—	Malaria ...	Recovery
Present (slight) up to 16.5.14 No bile, &c.	Present, fading on 16.5.14	? Hæmatogenous	Present	Malaria	*Rhabdonema* embryos numerous	Malaria with Strongyloid infection	Recovery
Present (slight)	None		Present	Malaria	—	Malaria ...	Recovery
Urine not obtainable	None	—	Present	Malaria		Malaria .	Recovery
None	None		Present	Malaria	—	Malaria ...	Recovery ? Reinfected. Same case as No. 24
Present (slight) up to 22.5.14. Recurred 26.6.14	None		Present	Malaria	*Ascaris l.* ... *Strongyloides* ...	Malaria with Helminthiasis	Recovery

FEVER CASES, QUITTAH,

No.	Date.	Tribe, &c.	Age.	Sex.	Temperature at time of taking Film.	Quinine.	Clinical Symptoms.	Parasites.
54	18.5.14	Alduna	7/12	M.	T. 100° F. P. 120	None	Fever ... ... Diarrhœa Stomatitis	? Subtertian... Pigmented mononuclears
55	18.5.14	Alduna	2	F.	T. 105° F. P. 180	None	Fever ... ... Splenic enlargement Severe anæmia Vomiting	Subtertian ... Pigmented mononuclears
56	19.5.14	Mulatto	4	M.	T. 100·8° F. P. 124	None	Fever ... ... Splenic enlargement Impetigo	Subtertian ... Pigmented mononuclears
57	19.5.14	Alduna	4 1/2	F.	T. 103·4° F. P. 142	None	Fever ... ... Headache Epigastric pain Diarrhœa Cough Severe anæmia	Subtertian ... Pigmented leucocytes
58	21.5.14	Alduna	5	F.	T. 98° F. P. 100	None	Diarrhœa ... ... Bronchitis Splenic enlargement	None ... Copious pigment in thick film
59	21.5.14	Alduna	25	M.	T. 102·7° F. P. 104	None	Fever ... ... Frontal headache Pains in legs and abdomen Albuminuria	None ...
60	22.5.14	Alduna	1 6/12	F.	T. 104·8° F. P. 140	None	Fever ... ... Albuminuria	Subtertian ... Pigmented mononuclears
61	22.5.14	Alduna	1 7/12	F.	T. 104°F. P. 139	None	Fever ... . Splenic enlargement	Subtertian ... Pigmented mononuclears
62	23.5.14	Alduna	1 1/2	M.	T. 103·8°F. P. 176	None	Fever ... ... Splenic enlargement Albuminuria	Subtertian ... Pigmented mononuclears
63	23.5.14	Kposo	26	M.	T. 101·8°F. P. 140	None	Fever ... ... Jaundice Epigastric pain Photophobia Vertigo Albuminuria Splenic enlargement on 30.5.14	None ... Subtertian on 30.5.14
64	25.5.14	Alduna	1 6/12	F.	T. 104°F. P. 160	None	Fever ... ... Diarrhœa	Subtertian ...
65	25.5.14	Alduna	1/12	F.	T. 100°F. Pulse uncountable	None	Fever ... . Splenic enlargement	Subtertian ...

MAY AND JUNE, 1914—*continued.*

Albuminuria.	Jaundice.	Cause of Jaundice.	Fever.	Cause of Fever.	Ova in Stools.	Diagnosis.	Remarks.
Urine not obtainable	None	—	Present	Malaria	—	Malaria with Stomatitis	Recovery
None	None	—	Present	Malaria	*Ascaris l.* ...	Malaria with Ascariasis	Recovery
None	None	—	Present	Malaria	—	Malaria with Impetigo	Recovery
None	None	—	Present	Malaria	*Ascaris l.* ...	Malaria with Ascariasis	Recovery
Compound protein	None	—	?	—	—	Malaria with Bronchitis	Recovery
Severe and persistent	None	—	Present	? Helminthic	*Ankylostomum d.*	Ankylostomiasis	Improved. Refused treatment. (*See* Notes)
Present (slight)	None		Present	Malaria		Malaria ...	Recovery
None	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (trace)	Present	—	Present	Malaria	—	Malaria ..	Recovery
Severe	Present	?	Present	Yellow fever	*Ankylostomum d.*	Yellow fever	Recovery "Seidelin body" on 26.5.14 (*See* Notes)
Urine not obtainable	None	—	Present	Malaria	None	Malaria ...	Recovery
Urine not obtainable	None	—	Present	Malaria	—	Malaria ...	Recovery

No.	Date.	Tribe, &c.	Age.	Sex.	Temperature at time of taking Film.	Quinine.	Clinical Symptoms.	Parasites.
66	26.5.14	Alduna	5	F.	T. 101·6°F. P. 144	None	Fever ... ... Splenic enlargement	Subtertian ... Pigmented mononuclears
67	26.5.14	Alduna	6	M.	T. 99·6°F.	None	Fever ... ... Splenic enlargement	Subtertian ... Pigmented leucocytes
68	28.5.14	Alduna	3	F.	T. 100°F. P. 100	None	Fever ... ... Headache Vomiting Splenic enlargement	None found... Many pigmented mononuclears
69	28.5.14	Alduna	6	M.	T. 101·8°F. P. 102	None	Fever ... ... Vomiting Epigastric tenderness Frontal headache	Subtertian ... Pigmented mononuclears
70	28.5.14	Alduna	2½	F.	T. 105°F. P. 150	None	Fever	Subtertian ... Pigmented leucocytes
71	29.5.14	Alduna	5	M.	T. 104·6°F. P. 109	None	Fever ... ... Convulsions	Subtertian ...
72	29.5.14	Alduna	6	F.	T. 99°F. P. 100	None	Fever ... ... Vomiting	Subtertian ...
73	30 5.14	Alduna	4½	M.	T. 103°F. P. uncountable	None	Fever ... ... Strabismus Vertical nystagmus Tonic spasms Trismus Head retraction Kernig's sign Coma Splenic and Lepatic enlargement	Subtertian ... (in enormous numbers)
74	30.5.14	Alduna	16	F.	T. 100°F. P. 98	None	Fever ... ... Frontal headache Pain in neck, back and legs Anæmia Splenic enlargement	Subtertian ...
75	1.6.14	Alduna	1½	F	T. 103·6 F. P. 160	None	Fever ... ... Convulsions Stupor Vomiting	Subtertian ...

MAY AND JUNE, 1914—*continued.*

Albuminuria.	Jaundice.	Cause of Jaundice.	Fever.	Cause of Fever.	Ova in Stools.	Diagnosis.	Remarks.
Present (slight)	None		Present	Malaria	—	Malaria ...	Recovery
Urine not obtainable	None	—	Present	Malaria	—	Malaria ..	Recovery
None ... ... Compound protein	None	—	Present	Malaria	—	Malaria ...	Recovery
None	None	—	Present	Malaria	—	Malaria ...	Recovery
None	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (slight opalescence)	None	—	Present	Malaria	—	Malaria ..	Recovery
Urine not obtainable	None	—	Present	Malaria	*Ascaris l.* ..	Malaria with Ascariasis	Recovery
Urine not obtainable	None	-	Present	Malaria	—	Malaria ...	Died 2 p.m., 30.5.14
Present (marked)	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (trace) ...	None	—	Present	Malaria	—	Malaria ..	Recovery

FEVER CASES, QUITTAH,

No.	Date.	Tribe. &c.	Age.	Sex.	Temperature at time of taking Film.	Quinine.	Clinical Symptoms.	Parasites.
76	1.6.14	Alduna	6	F.	T. 98·8°F. P. 140	None	Fever	Subtertian ...
77	1.6.14	Alduna	1½	F.	T. 103°F. P. 176	None	Fever ... ... Colic Convulsions Diarrhœa	None ... No pigment in thick Film
78	2.6.14	Alduna	4	M.	T. 100·4°F. P. 100	None	Fever ... ... Abdominal pain	Subtertian ... Pigmented leucocytes
79	4.6.14	Alduna	36	M.	T. 99·3°F. P. 88	None	Fever	Subtertian ...
80	4.6.14	Alduna	7	M.	T. 99·6°F. P. 88	None	Fever ... ... Colic	Subtertian ...
81	4.6.14	Alduna	26	F.	T. 100·2°F. P. 104	None	Fever ... ... Anæmia Œdema, legs and feet	Tertian ...
82	4.6.14	Alduna	7	M.	T. 99·8°F. P. 89	None	Fever ... ... Splenic enlargement	Subtertian ..
83	4.6.14	Alduna	6	M.	T. 104°F. P. 117	None	Fever ... ... Headache Conjunctival injection Splenic enlargement Vomiting	Subtertian ..
84	5.6.14	Grunshi	26	M.	T. 101·6°F. P. 96	None	Fever ... ... Tenderness over liver Pulmonary congestion Albuminuria	None ..
85	5.6.14	Alduna	28	F.	T. 99°F. P. 84	None	Fever ... ... Pain chest and back	Subtertian ...
86	5.6.14	Grunshi	?	M.	T. 104·8 F. P. 116	None	Fever ... ... Splenic enlargement	Subtertian .

MAY AND JUNE, 1914—*continued.*

Albuminuria.	Jaundice.	Cause of Jaundice.	Fever.	Cause of Fever.	Ova in Stools.	Diagnosis.	Remarks.
Present (trace) ...	None	—	Present	Malaria	—	Malaria ...	Recovery
Urine not obtainable	None	—	Present	?	None	? Enteritis ...	Died 11.6.14
None	None	—	Present	Malaria	*Ascaris l.* ...	Malaria with Ascariasis	Recovery
None (large mucous casts)	None	—	Present	Malaria	—	Malaria ...	Recovery
None	None	—	Present	Malaria	*Ascaris l.* ...	Malaria with Ascariasis	Recovery
None ... ... Compound protein Epithelial casts and débris	None	—	Present	Malaria	—	Malaria ...	Recovery
None	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (trace) ...	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (marked) Bile salts on 6.6.14	None	—	Present	?	*Rhabdonema* embryos	Helminthiasis with pulmonary congestion	Recovery (*See* Notes)
None	Slight	?	Present	Malaria	*Trichocephalus tr.* *E. hystolitica* on 12.6.14	Malaria followed by Dysentery	Recovery
None	None	—	Present	Malaria	—	Malaria ...	Recovery

FEVER CASES, QUITTAH,

No.	Date.	Tribe.	Age.	Sex.	Temperature at time of taking Film.	Quinine.	Clinical Symptoms.	Parasites.
87	8.6.14	Alduna	1	M.	T. 103°F. P. 120	None	Fever ... ... Purulent ophthalmia Cough	Subtertian ...
88	11.6.14	Alduna	7	F.	T. 101·6°F. P. 130	None	Fever	Tertian ...
89	11.6 14	Alduna	1	M.	Not taken	None	Fever ... ... Stupor	Subtertian ...
90	11.6.14	Alduna	45	M.	See Notes	None	Fever ... . Conjunctival injection Splenic enlargement Albuminuria	None ...
91	11.6.14	Alduna	2½	M.	T. 98°F. P. 76	None	Fever	Subtertian ...
92	11.6.14	Alduna	18	M.	T. 100°F. P. 119	None	Fever ... ... Headache Vomiting Diarrhœa Conjunctival injection Albuminuria	Tertian
93	12.6.14	Alduna	Adult	F.	T. 100°F. P. 99	None	Fever ... ... Articular pain Anæmia	Subtertian ..
94	12.6.14	European	43	M.	T. 98·4 F. P. 144	None	Fever ... ... Vomiting (? alcoholic)	Tertian ...
95	15.6.14	Alduna	2	F.	T. 102 F. P. 110	None	Fever	Subtertian ...
96	15.6.14	Alduna	22	M.	T. 100·3 F. P. 96	None	Fever ... ... Pulmonary congestion Albuminuria	None ...
97	15.6.14	Alduna	4	F.	T. 103·8 F	None	Fever ... ... Splenic enlargement Anæmia	Tertian and Subtertian

MAY AND JUNE, 1914—*continued.*

Albuminuria.	Jaundice.	Cause of Jaundice.	Fever.	Cause of Fever.	Ova in Stools.	Diagnosis.	Remarks.
Urine not obtainable	None	—	Present	Malaria	—	Malaria with Ophthalmia	Recovery
None	None	—	Present	Malaria	—	Malaria ...	Recovery
None ... ... Compound protein	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (marked)	None	—	Present	? Typhoid	*Ascaris l.* ... *Trichocephalus tr.*	Typhoid ..	Recovery "Seidelin bodies" on 13.6.14 (*See* Notes)
None	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (slight)	None		Present	Malaria	—	Malaria ..	Recovery
None	None		Present	Malaria	—	Malaria ...	Recovery
None	None	-	Present	Malaria	None	Malaria ...	Recovery
Urine not obtainable	None	—	Present	Malaria	—	Malaria ..	Recovery
Severe ... .. (? Gonorrhœal)	None		Present	Pulmonary congestion	*Trichocephalus l.*	Pulmonary congestion	Recovery "Seidelin bodies," 15 and 16.6.14
Urine not obtainable	None	—	Present	Malaria	—	Malaria ...	Recovery

FEVER CASES, QUITTAH,

No.	Date.	Tribe.	Age.	Sex.	Temperature at Time of taking Film.	Quinine.	Clinical Symptoms.	Parasites.
98	17.6.14	Atsina	26	M.	T. 102·8 F. P. 85	None	Rigor ... ... Headache Loin pains Fever Faget's sign Albuminuria Conjunctival injection	None ...
99	17.6.14	Alduna	17	M.	T. 99·2° F. P. 74	None	Rigor ... ... Fever Jaundice Pain over liver Vomiting Albuminuria	None ...
100	19.6.14	Alduna	1 1/2	M.	T. 103 F. P. 140	None	Fever ... . Vomiting Albuminuria	Tertian ...
101	22.6.14	Alduna	17	F.	T. 102·6° F. P. 120	None	Fever ... ... Headache Albuminuria	Present (very scarce) ? species
102	23.6.14	Alduna	7	M.	T. 103·6° F. P. 140	None	Fever ... . Headache Splenic enlargement	Tertian Many pigmented leucocytes
103	24.6.14	Mulatto	12	M.	T. 104·8° F. P. 145	None	Rigor ... ... Fever Headache Splenic enlargement	Tertian ...
104	25.6.14	Alduna	6	F.	T. 101·8° F. P. 120	None	Fever ... . Diarrhœa Cough Albuminuria	? Quartan Pigment in mono- and polynuclears
105	25.6.14	Alduna	1 1/2	F.	T. 99·6° F. P. 120	None	Fever ... . Splenic enlargement	Tertian ...
106	25.6.14	Alduna	2	F.	Not noted	None	Fever ... . Splenic enlargement Albuminuria Anæmia	Tertian ...

May and June, 1914—*continued.*

Albuminuria.	Jaundice.	Cause of Jaundice.	Fever.	Cause of Fever.	Ova in Stools.	Diagnosis.	Remarks.
Present (slight)...	Present	? Hæmatogenous	Present	Yellow Fever	[illegible] ...	Yellow Fever	Recovery (*See* Notes)
Present (slight) on 17.6.14 only	Present	?	Present	?	—	?	Recovery
Present (opacity)	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (slight)...	None	—	Present	? Typhoid	None	? Typhoid ...	Recovery "Seidelin bodies" found (*See* Notes)
None	None		Present	Malaria	—	Malaria ...	Recovery
None	None	—	Present	Malaria		Malaria	Recovery
Present ... .. Deposit contains granular casts and epithelial débris	None	—	Present	Malaria	—	Malaria	Recovery
Urine not obtainable	None	—	Present	Malaria	—	Malaria ...	Recovery
Present (trace) ...	None	—	Present	Malaria	[illegible] ...	Malaria with Ascariasis	Recovery

Case 59.

THE CASE OF OKPITA

21.5.14. Okpita, male, 25, Alduna. "I had abdominal pain yesterday morning. Fever commenced last night."

Temperature 102, pulse 104, weak and compressible. Pain in legs and lower part of abdomen. Slight epigastric tenderness. Eyes moist and slightly injected. Blood: No parasites. Urine: Heavy deposit of albumin on boiling. ℞ Sp. Aetheris Nitr. ʒss, Liq. Am. Acet. Con. ʒss. statim.

2.30 p.m. Temperature 100, pulse 82, tension increased. Urine, 6 ozs.; albumin $\frac{1}{4}$.

3.20 p.m. Blood: No parasites and no pigment.

8.30 p.m. Temperature 99·4, pulse 82-84, of fair tension. Urine, 8 ozs., albuminous. Strong sweat.

22.5.14.—Urine: 5.30 a.m., 2 ozs.; albumin $\frac{1}{3}$.

7.5 a.m. Urine, 7 ozs., albumin $\frac{1}{4}$.

8 a.m. Temperature, 99. Blood: No pigment and no parasites.

1.5 p.m. Urine: Albumin $\frac{1}{3}$.

3.15 p.m. Temperature 98·6, pulse 95. Blood: No pigment and no parasites.

7.30 p.m. Blood: No pigment and no parasites.

9 p.m. Urine: Albumin $\frac{1}{3}$.

23.5.14.—Temperature 98·4, pulse 76. Urine, albumin $\frac{2}{7}$. Stool: Very numerous ankylostome eggs.

12 a.m. Urine 6 oz., albumin $\frac{1}{4}$.

3.40 p.m. Temperature 98·4, pulse 80. Discharged under observation.

24.5.14.—Temperature 98, pulse 76. Albumin $\frac{2}{5}$.

25.5.14.—Urine, albumin $\frac{2}{5}$.

1.6.14.—Temperature 98·4, pulse 75. Urine: Albumin $\frac{1}{20}$.

Is suffering from ankylostomiasis, and refuses treatment.

Medical Department, Gold Coast Colony.

Name of Station Quittah

CLINICAL CHART OF TEMPERATURE

Name Okpita, male Age 25 Disease Result

Date of Observation	May 21	22	23	24	25	26	27	28	29	30	31	June 1
Day of Disease	2	3	4	5	6	7						

Temperature taken at 6 a.m. and 4 p.m.

Ankle Lost

	M/E																									
Pulse	M	104			76	76											75									
	E	83	95		80																					
Resp.	M																									
	E																									
Oz. in 24 hours																										
Reaction of																										
Specif. Gr. of																										
Colour of																										
Urea (amount)																										
Albumen in		+	+	+	+												+									
Solids in																										
Micros. Sediments																										

Admitted to Hospital
21 May 1914

Description
Goldsmiths Apprentice

Discharged
28 May 1914

Case 63.

THE CASE OF KPESU.

Kpesu, male, aged 26, scavenger, from Kposo in Togoland, resident five months in Quittah, was admitted to hospital 23.5.1914.

"He was suddenly taken ill on May 20th, while working in the market-place. The illness commenced with abdominal pain, then pain in back, shoulders and neck, and strong frontal headache. He had a serious rigor lasting until the next day, and was confined to his bed with a strong fever for three days, during which time he was very weak, could not take food, and had looseness of the bowels. On the 23rd he felt a little better and came to hospital."

State on admission: Temperature 101·8, pulse 140. Marked prostrations. Tongue coated, cleaner at tip and edges. Vertigo. Eyes injected. Photophobia. Distinct jaundice of scleræ. Great tenderness to pressure over epigastrium. Spleen and liver not palpable—any handling causes great pain. Pain around shoulders and back of neck. No nausea. Urine: Acid, heavy deposit of albumin. Blood: No malarial or other parasites. Two pigmented leucocytes found in thick film after prolonged examination. Normoblasts.

Polynuclears	29·4
Lymphocytes	68·0
Mononuclears	1·6
Neutrophil Myelocytes	1·0
	100·0

11 a.m. Blood: No parasites and no pigment (examination 1¼ hours):—

Polynuclears	32·2
Lymphocytes	65·6
Irritation forms	0·2
Mononuclears	1·2
Neutrophil Myelocytes	0·8
	100·0

12 a.m. 3½ ozs. urine: acid, high-coloured, slightly turbid. Albumin ⅛. No bile salts or pigment. Deposit: A few pus cells and a few very small casts.

Patient states he had gonorrhœa since four months ago.

3.13 p.m. Urine 4 ozs.: acid, albumin $\frac{1}{10}$.

3.40 p.m. Temperature 102·6, pulse 120.

4.30 p.m. Blood: No parasites and no pigment (thick film, 15 minutes).

24.5.14.—5.50 a.m. Urine 10½ ozs., acid, albumin $\frac{1}{16}$.

6 a.m. Temperature 99° F., pulse 78.

9.50 a.m. Temperature 98·4, pulse 75.

9.55 a.m. Urine: 6½ ozs., acid, albuminous. Stool: Eggs of *Ascaris l.*, and *ankylostomum*.

10.45 a.m. Blood: No parasites, 1 pigmented leucocyte in thick film (15 minutes).

11 a.m. Jaundice pronounced. Tongue clean at tip and edges, whitish fur on dorsum, the papillæ showing as red points. Glabellar headache and severe epigastric pain. Marked prostration. Pulse 94.

3 p.m. No headache. Pain over epigastrium and liver. Temperature 99·7, pulse 81, weak and compressible. Blood: No parasites and no pigment (½ hour).

4.30 p.m. Temperature 100, pulse 99.

6.40 p.m. Urine 6½ ozs., albumin = $\frac{1}{10}$.

6.45 p.m. Temperature 101, pulse 100.

8.30 p.m. Temperature 98·8, pulse 76. Epigastric pain.

25.5.14.—1.5 a.m. Urine 7 ozs., acid, albuminous

3.50 a.m. Urine 6½ ozs., acid, albuminous.

8.30 a.m. Urine 3½ ozs., high-coloured, turbid, deposit contains granular casts, albumin $\frac{1}{20}$.

9.20 a.m. Temperature 97·8, pulse 96. Blood: No parasites, 2 pigmented mononuclears in thick film.

2.40 p.m. Temperature 98·6, pulse 92. Blood: No parasites and no pigment. Urine 7½ ozs., clear, albumin = transparent opacity, no deposit on centrifuging. No headache or epigastric tenderness. No splenic enlargement.

4.30 p.m. Urine 1½ ozs., clear, acid, albumin = opacity.

7 p.m. Urine 9 ozs., clear, albumin = opacity.

9.20 p.m. Urine 8½ ozs., clear, acid, albumin = faint opacity. Epigastric pain. No headache. Temperature 97·4, pulse 98, feeble and compressible. Patient is very weak.

26.5.14.—8 a.m. Urine 6½ ozs., high-coloured, clear, acid, albumin = transparent opacity.

10.45 a.m. Temperature 98·4, pulse 91. Jaundice is fading. Epigastric tenderness. No headache. Blood: No parasites and no pigment, 1 "Seidelin body."

3.10 p.m. Urine 6 ozs., clear, acid, albumin = transparent opacity.

4 p.m. Temperature 99·4, pulse 96. Blood: No parasites, 4 pigmented mononuclears in thick film (¾ hour).

27.5.14.—6.30 a.m. Temperature 98·6, pulse 99. Urine 4 ozs., clear, very faint trace of albumin, and some compound protein. ℞ T. Strophanth. ♏ x., T. Nucis Vomic., ♏ x., T. Gent. Co. ♏ x. Aq. ad ℥j. t.d.s.

3 p.m. Temperature 98·4, pulse 93. Tongue clean. Jaundice fading. Marked improvement of general condition: patient looks bright, feels stronger, no headache, etc. Appetite is asserting itself. Urine: Acid, clear, albumin = faint opacity.

28.5.14. 9 a.m. Urine: clear, acid, no deposit, albumin = opacity. Temperature 98·4, pulse 75. Jaundice still distinct, but lessening.

10 a.m. Pulse 95. Discharged under observation.

29.5.14.—9 a.m. Urine acid, Albumin = marked opacity. Temperature 98·4, pulse 92. Jaundice present. Spleen and liver not palpable.

30.5.14.—3 p.m. Feels ill to-day. Temperature 100, pulse 100. Spleen palpable at costal margin. Blood: Tertian parasites. Quinine.

1.6.14.—Temperature 99·8, pulse 99. Jaundice very slight. Tongue clean. Spleen palpable. Urine: Albumin = lessening opacity.

Patient left the town without reporting himself again.

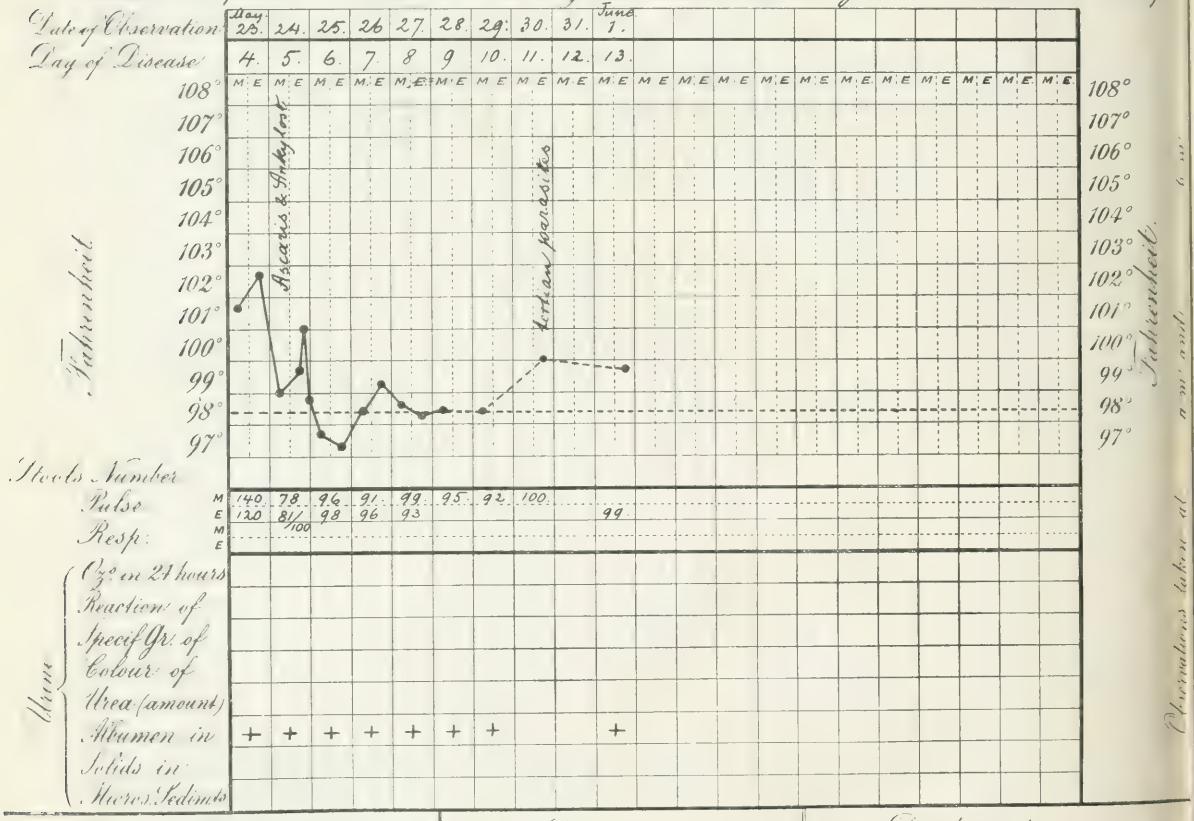
Diagnosis: Yellow Fever.

Medical Department, Gold Coast Colony.

Name of Station Quittah

CLINICAL CHART OF TEMPERATURE

Name Kpesu, male *Age* 26 *Disease* Y.F. *Result* Recovery


Date of Observation
Day of Disease
Day 25. 24. 25. 26. 27. 28. 29. 30. 31. June 1.
4. 5. 6. 7. 8. 9. 10. 11. 12. 13.
M E
108° 107° 106° 105° 104° 103° 102° 101° 100° 99° 98° 97°
Ascaris & Anky. lost.
Tertian parasites
Temperature
Stools Number
Pulse
Resp:
M 140. 78. 96. 91. 99. 95. 92. 100.
E 120. 81/100 98 96 93 99
Urine
Ozs in 24 hours
Reaction of
Specif Gr. of
Colour of
Urea (amount)
Albumen in + + + + + + +
Solids in
Micros. Sediments

Admitted to Hospital 25 May 1914

Description: Scavenger

Discharged 28 May 1914.

Case 84.

THE CASE OF BATIA GRUNSHI.

5.6.14.—Batia Grunshi, male, 26, Grunshi, police constable. States he had "fever in bush. Came back five days ago. Yesterday pain all over." Temperature 101·6, pulse 96. Headache. Tongue flabby, coated, and indented. Tenderness over liver. Liver and spleen not palpable. Urine: Acid, albumin = marked opacity. Blood: No parasites.

℞ Phenacetin Compound gr. x. Diaphoretic mixture.

6.6.14.—Temperature 100, pulse 99. Urine dark brown, acid, albumin = marked opacity. Bile salts present (Hay's test).

2 p.m. Temperature 100, pulse 77. Tenderness over liver. Blood: No parasites.

7.6.14.—Temperature 100, pulse 99. Persistent pain over right lobe of liver. No enlargement of liver or spleen. Dulness and impaired breath over lower lobe of right lung. No adventitious sounds. Urine: Dark, turbid, trace of albumin, no bile or bile salts. Blood: No parasites. Stool: *Rhabdonema.*

2.30 p.m. Temperature 102·6, pulse 92. Slight headache. Urine: Clear, acid, albumin a trace. No bile, &c.

8.6.14.—7.55 a.m. Temperature 101, pulse 99. Urine: Albumin = opacity.

3 p.m. Temperature 100, pulse 99.

9.6.14.—7 a.m. Temperature 100, pulse 98. Urine: Dark, clear, acid, albumin = dense opacity.

4 p.m. Temperature 99·9, pulse 98.

10.6.14.—Morning, temperature 99·6; evening, temperature 98·6.

11.6.14.—Morning, temperature 98·8. Very harsh, almost tubular breathing over right base. albumin = opacity. Discharged.

15.6.14.—Temperature 98, pulse 76. Urine free from albumin. Chest has cleared up.

Medical Department, Gold Coast Colony.

Name of Station Quittah

CLINICAL CHART OF TEMPERATURE

Name Batia Gruenshe, Male Age 26 Disease Pulm. & congestion Results Recovery

Date of Observation (June 1914)	5	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
Day of Disease	2	3.	4	5.	6	7.	8.														

Fahrenheit: 108° 107° 106° 105° 104° 103° 102° 101° 100° 99° 98° 97°

Rhabdomyoma

Stools Number																					
Pulse	M	96	99	99	99	98						76									
Resp:	E		77	92	99	84															
	M																				
	E																				

Urine:
- Oz in 24 hours
- Reaction of
- Specf Gr. of
- Colour of
- Urea (amount)
- Albumen in — + + + + + Nil
- Solids in
- Micros Sediments

Fæces: Fair sized

Admitted to Hospital	Description	Discharged
5th June 1914.	Police Constable.	11.6.14

Case 90.

THE CASE OF TETTEH.

11.6.14.—Tetteh, male, Alduna, from Jellerkophe. "Fever five days, all the time." Eyes injected. Pain in right eye. Temperature 103° F., pulse 100. Urine: Clear, acid, albumin = marked opacity. No parasites.

4.5 p.m. Temperature 103·6° F., pulse 80. Sudden profuse sweat. No parasites.

12.6.14.—6.40 a.m. Temperature 103, pulse 101. Urine: Albumin = marked opacity.

10 a.m. Temperature 102·9° F.

12.30 p.m. Temperature 103·2, pulse 88. Blood: No parasites.

4 p.m. Temperature 104·2, pulse 120. Pain in loins.

13.6.14.—6.55 a.m. Temperature 101, pulse 99.

11.30 a.m. Temperature 103·2, pulse 100. Fainted.

Stool: *Ascaris l.* and *Trichocephalus tr.* Blood: No parasites. Two Seidelin bodies.

4 p.m. Temperature 104° F., pulse 99. Blood: No parasites. Pain in back and "sore throat."

8 p.m. Temperature 103·2° F., pulse 88.

14.6.14.—7 a.m. Temperature 103, pulse 98.

9 a.m. Urine: Albumin = faint opacity.

12.15 a.m. Temperature 103·2, pulse 83-86. Spleen enlarged. Some fulness of abdomen. Blood: No parasites.

4 p.m. Temperature 103·6°F., pulse 88. Pain in eyes.

6 p.m. Temperature 103·6° F., pulse 85. Blood: No parasites.

15.6.14.—7 a.m. Temperature 102·6, pulse 89.

8 a.m. Urine: Acid, albumin = transparent opacity.

10 a.m. Temperature 102, pulse 91.

4.30 p.m. Temperature 104, pulse 89. Cough. Spleen palpable.

16.6.14.—7 a.m. Temperature 100° F., pulse 82.

8.55 a.m. Urine: Albumin = slight opacity.

12 a.m. Temperature 102·6, pulse 82.

6 p.m. Temperature 102·6, pulse 84. Coughing frequently.

17.6.14.—Temperature 102·6, pulse 81. Urine: Albumin a trace.

4 p.m. Temperature 103·2° F., pulse 82.

7 p.m. Temperature 105, pulse 104. Sweating.

18.6.14.—8 a.m. Temperature 101·6, pulse 82. Urine, trace albumin.

2.30 p.m. Temperature 103, pulse 67. Urine, trace albumin.

7 p.m. Temperature 102, pulse 80. Stool after four days.

19.6.14.—7 a.m. Temperature 99·6, pulse 60. Urine, trace albumin.

11 a.m. Temperature 101·4° F., pulse 84.

6 p.m. Temperature 101·6, pulse 60. Sweating.

20.6.14.—Temperature 98·4, pulse 74. Urine: Albumin—a very faint trace.

7 p.m. Temperature 99·2, pulse 82.

21.6.14—Morning, temperature 98·4, pulse 75. Evening, temperature 98·2, pulse 76.

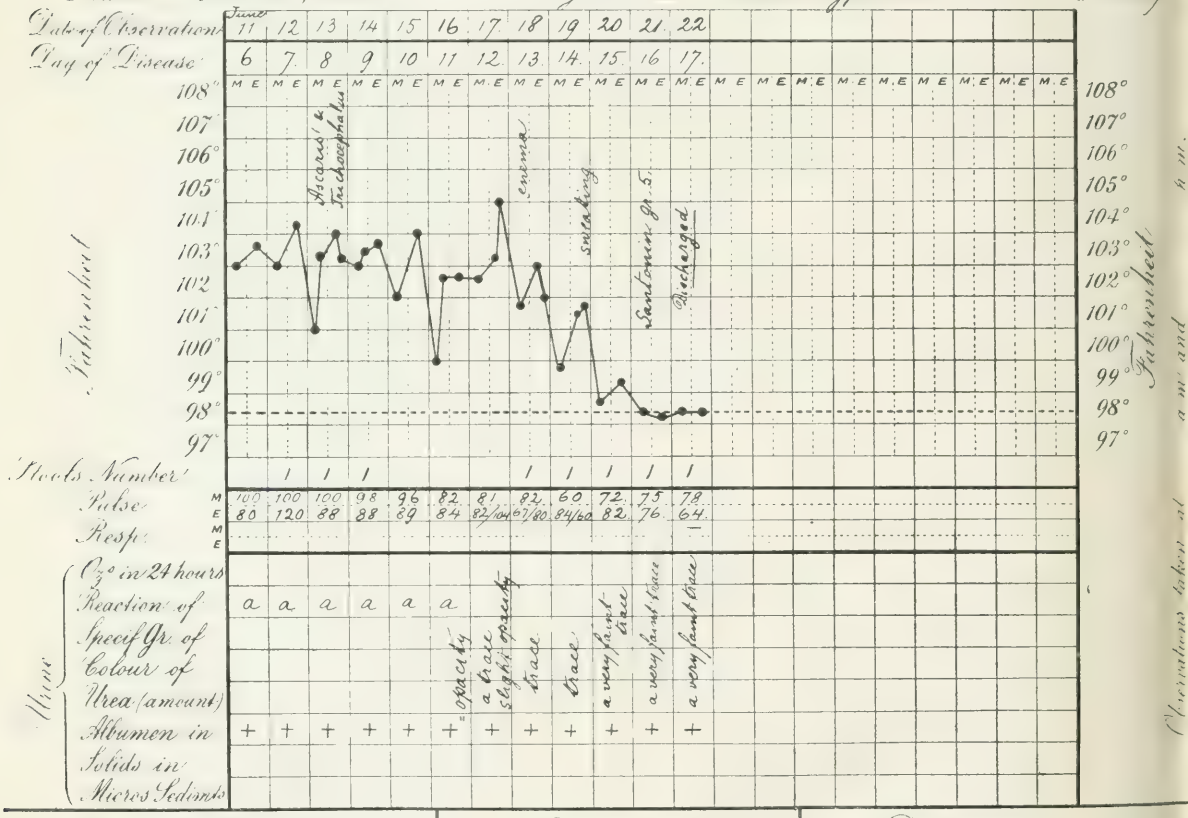
22.6.14.—Morning, temperature 98·4, pulse 78. Evening, temperature 99·4, pulse 64. Discharged.

Medical Department, Gold Coast Colony.

Name of Station Quittah

CLINICAL CHART OF TEMPERATURE

Name Tetteh, male Age 45 Disease Typhoid Result Recovery


Date of Observation
June 11 12 13 14 15 16 17 18 19 20 21 22
Day of Disease 6 7 8 9 10 11 12 13 14 15 16 17
M E M E M E M E M E M E M E M E M E M E M E M E
108° 107° 106° 105° 104° 103° 102° 101° 100° 99° 98° 97°
Fahrenheit
Hicaps & Tachycardia
enema
sweating
Sanitonin gr. 5.
Discharged
Stools Number 1 1 1 1 1
Pulse M 100 100 100 98 96 82 81 82 60 72 75 78
E 80 120 88 88 89 84 82/64 0/80 84/60 82 76 64
Resp. M E
Urine
Oz° in 24 hours
Reaction of a a a a a a
Specif Gr. of
Colour of
Urea (amount)
Albumen in + + + + + + + + + + + +
Solids in
Micros Sediments
opacity
a trace
slight opacity
trace
trace
a very faint trace
a very faint trace
a very faint trace

Admitted to Hospital	Description	Discharged
11. June 1914.	Farmer	

Case 90

THE CASE OF LAURENCE NETAKO.

15.6.14.—Laurence Netako, male, 22, Alduna, clerk. "On the 12th, pain in the left of chest. Coughing since then. That day also strong fever, rigors during night. Next day spat blood after coughing. Has improved since then. Gonorrhœa six months ago."

On admission: Pain left side. Impaired breath—sounds over left lung, no adventitious sounds. Blood: No parasites. "Seidelin bodies" found.

3 p.m Temperature 100·6, pulse 99. Coughing. Urine: Strongly acid, contains gonorrhœal threads, albumin $\frac{1}{3}$.

16.6.14—Temperature 100·3, pulse 96. Coughing. Râles and rhonchi over left base. Urine: Albumin $\frac{1}{20}$. Blood: No parasites. "Seidelin bodies" found.

17.6.14.—Temperature 100, pulse 99. Urine albuminous, opacity on boiling. Pulmonary symptoms more pronounced. Stool: *Trichocephalus tr.* Blood: No parasites.

20.6.14.—Temperature 98·9, pulse 86. Slight bronchitic cough. No pain. Urine: A trace of albumin.

22.6.14.—Temperature 98·8, pulse 84. Urine: Albuminous.

23.6.14.—Urine: Albumin $\frac{1}{20}$.

24.6.14.—Temperature 99, pulse 86. Urine: Small deposit of albumin.

25.6.14. Temperature 99·4, pulse 89. Urine: Albumin — opacity.

26.6.14. Temperature 98·4, pulse 88. Urine: Albumin $\frac{1}{20}$.

14.7.14.—Temperature normal. Urine: Albumin nil.

Case 98.

THE CASE OF KOFI.

17.6.14.—Kofi, male, 26, Atsim, police constable. Taken ill suddenly with rigor, pains in loins and violent headache. His temperature at 11 p.m. was 99, pulse 102. Hot fomentation.

On admission: Temperature 102·8, pulse 85. Urine: Compound protein, no albumin. Blood: No parasites. Stool: *Ascaris l.*

4 p.m. Temperature 103, pulse 92. Urine: Trace of albumin.

5 p.m. Temperature 102·6, pulse 83, regular, compressible. Conjunctivæ strongly injected. Tongue pointed, slightly coated on dorsum. All day there has been strong frontal headache and pains in loins.

7 p.m. Temperature 102, pulse 84.

18.6.14.—Temperature 98·8, pulse 74. Urine: Trace of albumin. Pain in loins and stomach. Tenderness over epigastrium No headache. Blood: No parasities. ? "Seidelin bodies."

2.30 p.m. Temperature 99·4, pulse 73, very regular. Urine: Trace of albumin. Blood: No parasites.

7 p.m. Temperature 99, pulse 63.

19.6.14.—7 a.m. Temperature 98·2, pulse 63. The eyes have a slight icteric tint. Urine: Trace of albumin.

11 a.m. Temperature 98·2, pulse 64.

6 p.m. Temperature 98·2, pulse 68.

20.6.14.—Temperature 98·4, pulse 75. Urine: No albumin.

4 p.m. Temperature 98, pulse 62. Icterus of scleræ has almost disappeared.

21.6.14.—Morning, temperature 98, pulse 74. Evening, temperature 98, pulse 56. Urine: No albumin.

22.6.14.—Morning, temperature 98·2, pulse 59. Urine: No albumin

23.6.14.—Temperature 98·4, pulse 64. Urine: No albumin.

24.6.14.—Temperature 98·8, pulse 64. Urine: Faint trace of albumin.

25.6.14.—Temperature 98·8, pulse 70. Urine: No albumin.

26.6.14.—Temperature 98·4, pulse 78. Urine: No albumin.

27.6.14.—Temperature 98, pulse 76. Urine: No albumin.

Medical Department, Gold Coast Colony.

Name of Station: Quittah.

CLINICAL CHART OF TEMPERATURE

Name: Kofi, male Age: 26 Disease: Y.F. Result:

Date of Observation	June 16	17	18	19	20	21	22	23	24	25
Day of Disease	1	2	3	4	5	6	7	8	9	10
M		85	74	63	75	74	59	64		
Pulse E	102	83/84	73/63	63	62	56	66			
Resp: M										
Resp: E										
Cc's in 24 hours										
Reaction of										
Spec: Gr: of										
Colour of										
Urea (amount)	a th of comma probably	a trace	trace	trace						
Albumen in	+	+	+	Nil	Nil	Nil	Nil	Trace	Nil	Nil	Nil
Solids in										
Micros: Sediment										

Temperature: 108° 107° 106° 105° 104° 103° 102° 101° 100° 99° 98° 97°

11 p.m. Acacia lumbricoides found spontaneously. Discharged.

Urine:

Observations taken at a.m. and p.m.

Admitted to Hospital 11 p.m. 16 June, 1914

Description: Police Constable

Discharged

Case 101.

THE CASE OF GRAN TAMAKLU.

22.6.14.—Gran Tamaklu, female, 17, Alduna. States she has had fever and headache three days, with constipation. Temperature 102·6, pulse 120. Urine: No albumin. Blood: No parasites. Mist. alb. and calomel gr. iii.

23.6.14.—11 a.m. Temperature 101·8. Headache. Bowels have moved freely. Urine: Trace of albumin. Blood: No parasites, no pigment. ? "Seidelin bodies." Phenacetin Compound gr. x.

24.6.14.—Temperature 102·8, pulse 118. Headache. Urine: Trace albumin, and small deposit of epithelial débris. Blood: No parasites. ? "Seidelin bodies." Admitted to hospital.

25.6.14.—Temperature 102·2, pulse 90. Urine: Trace of albumin.

11 a.m. Temperature 102, pulse 104. Slight headache. Blood: Malarial parasites (? species) very scarce. One "Seidelin body" found after $\frac{3}{4}$ hour.

3 p.m. Temperature 103·4, pulse 104. No headache. Urine: Turbid, deposit on centrifuging: epithelial débris and clumps of bacilli.

5 p.m. Temperature 103·2, pulse 104.

6.30 p.m. Temperature 102·2, pulse 102

26.6.14.—Temperature 102, pulse 92. Urine: Trace of albumin. Blood: No parasites.

3.40 p.m. Temperature 103·8, pulse 100.

5.30 p.m. Temperature 103·2, pulse 102.

27.6.14.—Temperature 102, pulse 102.

3.30 p.m. Temperature 103·4, pulse 112.

6 p.m. Temperature 103·2, pulse 104. Slight headache.

For further temperature see chart. Albuminuria continued up to July 14, when urine was found free from albumin.

Medical Department, Gold Coast Colony.

Name of Station Quittah.

CLINICAL CHART OF TEMPERATURE

Name Gran Tamaklu Sex Fem. Age 17 Disease ? Typhoid Race Fanteen

Date of Observation: June 22 23 24 25 26 27 28 29 30 July 2 3 4 5 6 7

Day of Disease: 4. 5. 6. 7 8. 9. 10. 11. 12 13. 14. 15 16 17 18 19

Temperature: 108° 107 106 105 104 103 102 101 100 99 98 97

M E M E M E M E M E M E M E M E M E M E M E M E M E M E M E M E M E M E

Subnormal

Pyrexia

Observations taken at 9 a.m. and 5 p.m.

Pulse: M 118 99/104 92 102 92 99 100 99 94 94 96 80 87 82 78 74

Pulse: E 120 104 104 104/104 99 90 97 97 88 84 88 84 82

Resp: M

Resp: E

Urine: Oz. in 24 hours

Urine: Reaction of

Urine: Specif. Gr. of

Urine: Colour of

Urine: Urea & amount — Trace, Trace, Trace, a faint trace, a faint trace

Urine: Albumen in — N.L + + + + +

Urine: Solids in

Urine: Mucus, Sediment — continued up to 14th when urine free from albumen

Admitted to Hospital	Description	Discharged
22 June 1914.		4 July 1914.

Treatment	Diet	Treatment

P
Med
Y

350471
Yellow Fever Commission (West Africa) Biological & Medical Serials
Investigators' reports

DATE | NAME OF BORROWER

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